PARTMENT OF TECHNOLOGY
BUFFALO PUBLIC LIBRARY

AERONAUTICAL ENGINEERING REVIEW

NOVEMBER 1953

LORD Dynafocal Engine Mountings

ON THE NEW DC 7

Safety . . . Speed . . . Comfort characterize the new Douglas DC 7, "the world's fastest piston-powered commercial airliner". Contributing to these factors, Lord MR43 Dynafocal Engine Mountings and Bonded-Rubber parts control vibration throughout the aircraft.

Lord Bonded-Rubber parts will help to protect your product from the damaging effects of vibration and shock . . . improve its performance. We invite you to make good use of our experience.

BURBANK, CALIFORNIA
233 South Third Street

CHICAGO 11, ILLINOIS
520 N. Michigan Ave.

CLEVELAND 15, OHIO
Room 811 Hanna Building

DALLAS, TEXAS
413 Fidelity Union Life Building

DAYTON 2, OHIO
410 West First Street

DETROIT 2, MICHIGAN
311 Curtis Building

NEW YORK 16, NEW YORK
280 Madison Avenue

PHILADELPHIA 7, PENNSYLVANIA
725 Widener Building

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Headquarters for
VIBRATION CONTROL

Cover—Enlarged scale model of the common drone fly showing the fly's halteres or balancers which serve a balancing or gyroscopic purpose in the fly's flight. This model, on exhibit at the American Museum of Natural History on loan from Sperry Gyroscope Company, Division of The Sperry Corporation, demonstrates how nature has employed gyroscopes of exceptional design for millions of years. The development of a new mechanical device, the Gyrotron® vibrating rate gyro, based on this principle, is announced for the first time in two papers appearing on pages 24 and 31 of this issue.

Editor
Welman A. Shrader

Managing Editor
Berneice H. Jarck

Assistant Editor
Rita J. Turino

Reviews Editor
F. J. Hanseghy, Jr.

News Editor
Beverly A. Dodge

Book Reviews Editor
John J. Glennon

Technical Advisers
Hugh L. Dryden
Robert R. Dexter
S. Paul Johnston

Advertising Manager
Joseph P. Ryan

Business Manager
Hugh C. Judge

Adv. Production Mgr.
R. N. Lipner

Western Office
7660 Beverly Blvd., Los Angeles 36, Calif.

SUBSCRIPTION RATES

Aeronautical Engineering Review: United States and possessions, 1 year, $3.00; single copies, $0.50. Foreign countries including Canada (American Currency Rates), 1 year, $3.50; single copies, $0.50.

Entered as second-class matter at the Post Office, Easton, Pa., April 29, 1942. Acceptance for mailing at a Special Rate of Postage as provided for in the Act of August 24, 1912.

Publication Office: 20th & Northampton Streets, Easton, Pa.

Editorial Office: 2 East 64th Street, New York 21, N.Y. Notices of change of address should be sent to the Institute at least 30 days prior to actual change of address.

Statements and opinions expressed in the Aeronautical Engineering Review are to be understood as individual expressions and not those of the Institute.

Copyright, 1953, by the Institute of the Aeronautical Sciences, Inc.

AERONAUTICAL ENGINEERING REVIEW

Vol. 12 NOVEMBER, 1953 No. 11

Contents

IAS News Notes 17
IAS News 19
Editorial 22

Articles

A New Space Rate Sensing Instrument . . . . . Joseph Lyman 24

General Theory and Operational Characteristics of the Gyrotron Angular Rate Tachometer . . . . Roland E. Barnaby, John B. Chatterton, and Fred H. Gerring 31

Fatigue Life of Thick-Skinned Tension Joints . . . . . Edward W. Thrall, Jr. 37

Evidences of an Inherent Error in Measurement of Total-Head Pressure at Supersonic Speeds . . . . . James S. Murphy 47

IAS Previews 55

Reviews

Aeronautical Reviews 71
Books 109
New Products and Product Literature 131–134

IAS Preprints 52
Sherman M. Fairchild Publication Fund Papers . . 56
Personnel Opportunities 121
Index to Advertisers 129

Published Monthly by the Institute of the Aeronautical Sciences, Inc.

How Parker tank-mounted valves save weight by allowing 25% smaller fuel line sizes

"When you specify fueling equipment, you've got many problems to consider. We believe the best solution is offered by tank-mounted diaphragm valves like these", reports Everett Badger, shown at the right. He is Chief Engineer of the Fuel Division at Parker Aircraft Co.

"You can save weight", Badger adds, "because the lower pressure drop of tank-mounted valves allows you to use about 25 per cent smaller line sizes. Their pressure drop of about 6 psi at 200 gpm is roughly one-half the loss through a similar valve mounted in the fuel line (including exit losses where fuel enters the tank). These savings let you use smaller, lighter lines without reducing the rate of flow to the tank. In addition, tank-mounted valves weigh about 40 per cent less.

"In the nearly ten years since Parker first started making diaphragm valves, we've never had one rupture in service.

"As for contaminant resistance, there are simply no close fits in this valve or the pilot valve where contaminant might jam.

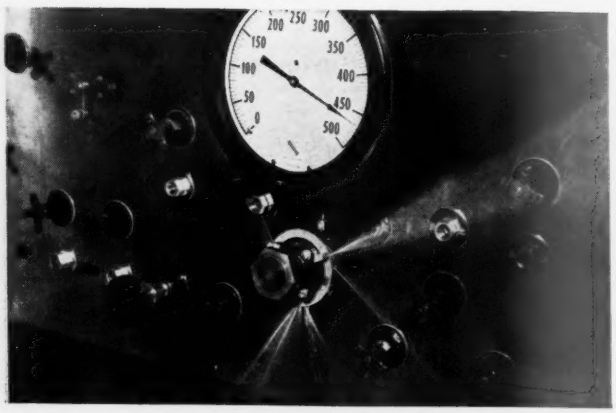
"The same basic diaphragm valve can easily include a second operating diaphragm unit to perform various functions such as flow proportioning or secondary fuel shutoff protection. Pilot line ports can be located on either the tube-inlet side or on top of the valve.

"Parker's pilot valves, like the one shown at the right, are available in single or dual styles with many auxiliaries. Because these valves are essentially pressure closed, there's no chance for 'hang-up' or faulty operation.

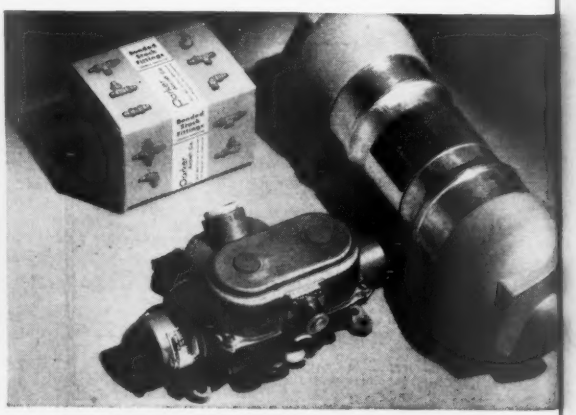
"A brand-new Parker booklet, 'Design Hints for Aircraft Fueling Systems', is just off the press. Send for your copy today."

PARKER AIRCRAFT CO.
5827 W. Century Boulevard, Los Angeles 45, California.
Subsidiary of The Parker Appliance Company

Parker
Hydraulic and fluid system components



Destruction test proves casting deflects far below 950 psi burst pressure of diaphragm. We've run millions of test cycles without failure of diaphragms.



What other components for hydraulic and fuel syste interest you? Parker Aircraft Co. builds a wide vari of engineered products for many different applicatio

I.A.S. News Notes

November 1953

AIR CARGO AND HEAVY PRESS MEETINGS NOV. 30-DEC. 2

The Institute is cosponsoring the technical sessions on Air Cargo and the Heavy Press Program in conjunction with the Annual Meeting of the A.S.M.E. this year, as usual. The meetings are being held at the Hotel Statler in New York, with Air Cargo sessions scheduled for November 30 to December 1, and the Heavy Press Program December 1 and 2.

A luncheon honoring engineers' contributions to powered flight, cosponsored by the A.S.M.E., I.A.S. and S.A.E., will feature Igor Sikorsky as principal speaker on Tuesday, December 1.

* * * * * * * *

INSTITUTE MEMBERS RECEIVE HIGH HONORS

Recognition for outstanding achievements was accorded three I.A.S. members this past month. Jerome Lederer (F) received the Arthur Williams Award, one of the major honors in the field of safety; William F. Gibbs, (AF) was presented the Franklin Medal, the highest honor given by the Franklin Institute; and Robert E. Gorton (M) was one of the two instrument engineers to win the S.A.E.'s Manly Memorial Award.

* * * * * * * *

INSTITUTE GRANTED REPRINT AND SALES RIGHTS ON EATON BOOK

The demand for copies of Eaton Manufacturing Company's "Fifty Years of Flight" was so great that the original supply of complimentary books was exhausted almost immediately. Through an agreement with Eaton Manufacturing Company the Institute has acquired the right to reprint and distribute additional sales copies of the book. A limited supply of these is now available at $5.00 per copy (less 10% discount to I.A.S. members.) A convenient coupon for ordering gift copies is incorporated in a full page ad appearing elsewhere in this issue.

* * * * * * * *

NATIONAL MEETINGS CALENDAR

Dec. 17 — Seventeenth Wright Brothers Lecture, U.S. Chamber of Commerce Building Auditorium, Washington, D. C. Glenn L. Martin, Lecturer.

Jan. 25-29 — Twenty-Second Annual Meeting and Honors Night Dinner, Hotel Astor, New York.

* * * * * * * *

I.A.S. News Notes (con't.)

CALENDAR OF SECTION MEETINGS

Nov. 4-- Chicago Section: Globe Corporation's Aircraft Division, Joliet, Ill. Dinner meeting, 6:30 p.m. Meeting to include plant tour and lectures on "Air Defense of the Chicago Area. Speakers not known at press time.

Nov. 4-- Philadelphia Section: The Franklin Institute, Philadelphia. Meeting, 8:00 p.m. "Progress and Problems in Air Safety" by Jerome Lederer, Managing Director, Flight Safety Foundation, Inc. Joint IAS -Franklin Institute meeting.

Nov. 4 -- Wichita Section: Meeting, 6:45 p.m. "Flight Safety" by R. M. Woodham, Administrator, Cornell-Guggenheim Aviation Safety Center. Location not known at press time.

Nov. 12-- San Diego Section: IAS Building. Technical meeting, 7:30 p.m. "Ceramic Coatings" by Mr. Long, Solar Aircraft Company.

Nov. 12-- Texas Section: Arlington State College, Arlington, Texas. Meeting, 8:00 p.m. Subject and speaker not known at press time.

Nov. 16-- Ottawa Aeronautical Society: RCAF Beaver Barracks, Argyle St., Ottawa. Meeting, 8:15 p.m. "The Upper Atmosphere" by Dr. P. Millman, Chief, Stellar Physics Division, Dominion Observatory.

Nov. 17-- Hagerstown Section: Hotel Alexander, Hagerstown, Md. Social hour and dinner, 6:00 p.m.; Meeting, 8:00 p.m. Discussion of the turbojet-turboprop transport by Don Conrad, Pratt & Whitney Aircraft Division, United Aircraft Corporation; L. R. Hackney, Transport Air Group; and William C. Lawrence, American Airlines, Inc. Presiding officer, Brig. Gen. D. J. Keirn, USAF, U. S. Atomic Energy Commission. A premeeting tour of Hagerstown plant of Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation, planned for 2:30 p.m. Joint meeting of Hagerstown and Washington Sections.

Nov. 17-- Washington Section: Joint meeting with Hagerstown Section. For details see Nov. 17 listing of Hagerstown Section.

Nov. 19-- Baltimore Section: The Johns Hopkins University. Meeting, 8:30 p.m. "Aeroballistics" by Dr. H. H. Kurzweg, Chief, Aeroballistics Research Dept., U.S. Naval Ordnance Laboratory.

Nov. 19-- Los Angeles Section: IAS Building. Social hour, 5:30 p.m.; Dinner, 6:30 p.m.; Meeting, 8:00 p.m. Annual business meeting with installation of officers. Speaker and subject not known at press time.

Nov. 19-- Texas Section: Subject, "Turboprop Engine Development." Location, time, and speaker not known at press time.

Dec. 3-- San Diego Section: IAS Building. Technical meeting, 7:30 p.m. "Applications of the Interferometer to Aerodynamics" by Arnold Ritter, Consolidated Vultee Aircraft Corporation.

Dec. 10-- San Diego Section: IAS Building. Technical meeting, 7:30 p.m. "Aircraft Flutter" by M. Dublin, Convair.

* * * * * * * *

IAS News

A Record of People and Events of Interest to Institute Members

IAS Twenty-Second Annual Meeting

Technical Program Being Planned by National Meetings Committee; Other Engineering Groups Cooperate in Sessions

T. P. Wright

THE TWENTY-SECOND ANNUAL MEETING of the Institute of the Aeronautical Sciences is scheduled for the week of January 25, 1954, at the Hotel Astor in New York. As is customary, the Honors Night Dinner will be held on the evening of the first day of the meeting in the Hotel Astor's Grand Ballroom and will be the scene of the presentation of IAS annual awards and honors.

As this issue goes to press, the Institute's National Meetings Committee, under the Chairmanship of T. P. Wright, Vice-President—Research at Cornell University, is formulating plans for one of the most outstanding meetings in the history of the Institute. These plans include five IAS-sponsored sessions and six sessions sponsored by the Institute in cooperation with other societies. The aforementioned IAS-sponsored sessions will cover Aerodynamics, Aeroelasticity, Structures, Aircraft Design, and Flight Propulsion.

According to the tentative plans, there will be two sessions—rather than the usual one session—on Rotating Wing Aircraft, which will be held cooperatively with the American Helicopter Society. The American Rocket Society is working with the Institute to present a session on Rocket Propulsion. A session on Air Transport—Safety will be given in cooperation with The Daniel and Florence Guggenheim Aviation Center at Cornell University. Two other scheduled cooperative sessions are on Meteorology with the American Meteorological Society and on Motorless Flight with the Soaring Society of America.

The National Meetings Committee, which is responsible for the planning of all IAS national meetings, is composed of persons from all parts of the United States. In addition to its Chairman, Dr. Wright, other members of this committee are: K. C. Black, of Polytechnic Research and Development Company, Inc.; Hugh L. Dryden, of NACA; Charles Froesch, of Eastern Air Lines, Inc.; Welco E. Gasich, of Northrop Aircraft Company, Inc.; Martin Goland, of the Midwest Research Institute; N. J. Hoff, of the Polytechnic Institute of Brooklyn; R. D. Kelly, of United Air Lines, Inc.; Jerome Lederer, of Flight Safety Foundation, Inc.; David S. Little, of American Airlines, Inc.; Harold Luskin, of Douglas Aircraft Company, Inc.; E. J. Manganiello, of NACA; Lewis A. Rodert, of NACA; W. R. Sears, of Cornell University; Abe Silverstein, of NACA; and Ernest G. Stout, of Consolidated Vultee Aircraft Corporation.

Wednesday, January 27, has been reserved for the presentation of three sessions on Electronics in Aviation. The plans for this day are being executed by a committee composed of representatives of the four participating societies—i.e., the Institute of Radio Engineers, Institute of Navigation, Radio Technical Commission for Aeronautics, and the Institute of Aeronautical Sciences.

At the Wednesday morning session, four papers of general interest will be presented. The topics to be discussed will be (1) recent developments in servomechanisms, (2) operational telemetering, (3) long-range navigation, and (4) magnetic amplifier—automatic pilot.

The value of electronic devices in the field of aviation personnel training, with particular emphasis on the training of military personnel in the maintenance of electronic equipment, will be discussed at the afternoon session. The first hour or so of this period will be given over to the presentation of four epitomes generally categorized as follows: (1) the military personnel training requirement; (2) personnel training required to produce large quantities of high-performance aircraft; (3) current methods and future needs in selecting aviation personnel; and (4) the major role to be played by training devices in aviation personnel training. The remaining portion of the afternoon session will be taken up by a symposium on the design and proper utilization of electronic training devices, which offer a great potential to both the services and industry in the aviation training problem.

The theme of the evening session is to be "The Airspace-Use Problem." The four papers scheduled to be delivered will consider (1) today's air traffic control procedures, (2) the shortcomings of the present air traffic control system, (3) the Air Navigation Development Board's program for the new air traffic

control system, and (4) the airspace-use problem. A question-and-answer period on this problem of airspace use will conclude the day on electronics in aviation.

In accordance with the provisions of the IAS Constitution, an Annual Business Meeting will be held on Wednesday, January 27. The hour will be 5:00 p.m. Official written notice of this business meeting, as well as the printed program containing full information on the Institute's Twenty-Second Annual Meeting, will be in the hands of IAS members before the end of this year.

Air Associates Joins IAS

The Institute of the Aeronautical Sciences announces a new Corporate Member, Air Associates, Inc., an organization founded in 1927. Air Associates, Inc., was originally incorporated under the laws of the State of New York; however, it is now a New Jersey Corporation with its headquarters and Aircraft Products Division located at Teterboro Air Terminal, Teteroboro, N.J.

Today, Air Associates, Inc., is composed of six divisions: the Aircraft Products Division at Teterboro, N.J.; the Electronic Equipment Division at Orange, N.J.; and the Aviation Supplies Divisions at Hackensack, N.J., Chicago, Ill., Glendale, Calif., and Dallas, Tex. The company also operates two branches in the Southeast which serve as outlets for aviation supplies. One of these branches is located at Atlanta, Ga.; the other is at Miami, Fla.

The aircraft Products Division designs, develops, and manufactures electromechanical, hydraulic, pneumatic, and special aircraft equipment which perform a variety of important functions on the modern fleets of civil and military aircraft. According to the company, a progressive engineering program, plus modern engineering and production facilities, has enabled the division to earn a reputation for high-quality dependable aircraft products.

The Electronic Equipment Division is engaged in research, development, and quantity production of a diversified number of electronic products for aviation and allied uses. This division is "an established producer" of low-frequency, very-high-frequency, and ultra-high-frequency communication and navigation systems, radio ranges, remote control systems, echo-ranging systems (including sonar), and special miniaturized electronic devices.

The Aviation Supplies Divisions distribute more than 2,000 different classes of "high-quality" finished products and maintenance materials to air lines, manufacturers, and airport service operators. The specialized service offered by these supplies-distributing divisions is said to provide the aviation industry with (1) a ready source for a wide variety of aviation products, ranging from abrasives to zinc chromate primer, (2) convenient buying locations, (3) less risk of product obsolescence before resale or use, (4) quick deliveries, and (5) savings in inventory maintenance and overhead costs.

Necrology

Charles W. Weaver, Jr.

Word concerning the death on May 22 of Charles Wilbur Weaver, Jr., TMIAS, after a prolonged illness was recently received at the IAS. Mr. Weaver was 22 years of age.

A native of Media, Pa., Mr. Weaver was graduated from the New Castle High School, New Castle, Pa., in June of 1948. Between September of that year and March of the following year, he attended the University of Pennsylvania as a premedical student. In 1949 and 1950, he was enrolled in Temple University's Evening School as a student in business administration. He studied aeronautical engineering through the Marine Corps Institute in Washington, D.C.

In January of 1952, he went to work for Prewitt Aircraft Company as a Junior Stress Engineer on helicopter rotor-blade structures. Mr. Weaver demonstrated a distinct talent for performing calculations fundamental to rotor-blade stress analysis. His responsibility as a Junior Stress Engineer, therefore, extended to the compilation of stress reports for helicopter rotor blades, including estimation of air loads, etc.

Testing Laboratory Formed by IAS Members

Two Institute members, Dr. Arthur Nutt, FIAS, and Harry J. Graham, MIAS, together with Richard Summers, comprise the executive of the newly formed organization, The Quality Control Company, of Bridgeport, Conn. Papers of incorporation were issued by the State of Connecticut on last August 3.

The company began operations in industrial X-ray about the first of September. However, it is expected that eventually the company will branch out to include all types of physical, chemical, and quality control testing, such as are conducted by a certified test laboratory.

Mr. Summers has left his former position as Metallurgist in charge of Radiography at Avco Manufacturing Corporation's Bridgeport-Lycoming Division to devote full time to the management of the new company. Dr. Nutt and Mr. Graham, while remaining at Bridgeport-Lycoming in their respective capacities as Director of Engineering and Contracts and as Chief Engineer, are acting as officers and directors of Quality Control.

The officers of the company are: President, Dr. Nutt; Vice-President and Secretary, Mr. Graham; and Treasurer and Technical Director, Mr. Summers.

News of Members

▶ **Ralph S. Damon** (F), President, Trans World Airlines, Inc., is a member of the Transport and Communications Committee recently formed by the Chamber of Commerce of the United States. This committee recommends ways of obtaining (1) clarification of federal-state relations in the field of transportation, (2) elimination of Government competition, and (3) less regulation.

▶ **Raymond M. Dussaigne** (AM) has moved to France as Field Representative of Piasecki Helicopter Corporation. Mr. Dussaigne is serving as Technical Consultant in the operation and maintenance of the MDAP HUP-2 helicopter assigned to the French Navy.

▶ **John W. Meyers** (M), Vice-President, Northrop Aircraft, Inc., was awarded the Night Fighter Association's first special service award for his work with the Northrop Black Widow P-61's during World War II. The presentation was made in Washington, D.C., on August 22.

▶ **Michael Stroukoff** (AF), Founder of Chase Aircraft Company, Inc., has disposed of his holdings in Chase and has established a new firm at West Trenton, N.J., known as Stroukoff Aviation Corporation. This new company has moved into the portion

of the Mercer County-owned Hangar 6E formerly occupied by Chase. Mr. Stroukoff is the designer of the C-123 Avitruc.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

Joseph V. Adornato (TM), with Grumman Aircraft Engineering Corporation. Formerly, Structural Test Engineer, Columbus Division, North American Aviation, Inc.

Niels C. Beck (M), Project Development Engineer, Armour Research Foundation, Illinois Institute of Technology. Formerly, Dean, Parks College of Aeronautical Technology of St. Louis University.

Adam Craigon (M), now Plant Manager, C. T. Electrical Controls Ltd., Canada.

John W. Drebinger (M), Member of the Technical Staff, Hughes Aircraft Company. Formerly, Assistant Project Engineer, Pratt & Whitney Aircraft Division, United Aircraft Corporation.

Lee H. Erb (TM), Power Plant Design, Helicopter Division, Bell Aircraft Corporation. Formerly, Development Engineer, Propulsion Controls, Helicopter Division, McDonnell Aircraft Corporation.

William K. Hilditch (M), Senior Test Engineer, A. V. Roe Canada, Ltd. Formerly, Performance Analysis Engineer, Avro Canada.

Ralph L. Hull (TM), Design Engineer, The Cessna Aircraft Company. Formerly, Design and Development Engineer, Beech Aircraft Corporation.

Lieutenant Commander John Huson, USNR (M), Executive Officer, Fleet Aircraft Service Squadron 103, NAS, Patuxent River, Md. Formerly, Material Review Analyst, Department of Quality Control Engineering, Republic Aviation Corporation.

Jesse J. King, Jr. (M), Lead Structures Design Engineer, Structures Design Group, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Structures Engineer, Stress Group, Northrop Aircraft, Inc.

James N. Lew (M), Vice-President—Contract Administration, Beech Aircraft Corporation. Formerly, Contracts Administrator, Beech.

John E. Martin, Jr. (M), Boeing Engineering Representative, Bell Aircraft Corporation. Formerly, Assistant Supervisor, Engineering Liaison Group, Wichita Division, Boeing Airplane Company.

Thomas A. McCarty (TM), Aerodynamics Section, Sverdrup & Parcel, Inc. Formerly, Second Lieutenant, USAF, Lowry AFB, Colo.

Frank E. McCreery (M), Vice-President—Engineering, Rohr Aircraft Corporation. Formerly, Executive Chief Engineer, Rohr.

George F. McLaughlin (M), Technical Editor, *Aero Digest*, New York. Formerly, Director, Aviation Research Division, Facts, Inc.

M. V. Riccius (TM), Senior Designer, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Lieutenant, USNR, Staff, CFAW-1, c/o F.P.O., San Francisco, Calif.

William F. J. Riordan (AM), Contract Administrator, Lockheed Aircraft Corporation. Formerly, Senior Negotiation Engineer, Aviation Gas Turbine Division, Westinghouse Electric Corporation.

J. C. K. Shipp (M), Aviation Group Representative (North America), The English Electric Company Limited, England. Formerly, Assistant Director (Plans), British Ministry of Supply.

David Roy Shoults (AF), General Manager, Aircraft Nuclear Propulsion Department, Atomic Products Division, General Electric Company. Formerly, Manager, Aircraft Nuclear Propulsion Project, Aircraft Gas Turbine Division, G-E.

Martin A. Snyder (M), Flight Test Engineer, Lockheed Aircraft Corporation. Formerly, Flight Test Engineer, Bell Aircraft Corporation.

J. D. Strickland (AM), Sales Manager—Aircraft Operations, Pacific Airmotive Corporation. Formerly, Manager, Sales and Service, Grand Central Aircraft Company.

James P. Sturrock (M), Aerodynamicist, Aerophysics Laboratory, North American Aviation, Inc. Formerly, Captain, USAF, Aerodynamics Research Group, Flight Research Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio.

Herman C. Wieben, Jr. (M), Chief Engineer, Chase Aircraft Company, Inc. Formerly, Chief Project Engineer, Chase.

Corporate Member News

• **Beech Aircraft Corporation**. . .According to a recent announcement, C. C. Pearson, Vice-President—Engineering, was elected to Beech Aircraft's Board of Directors. At the same time, James N. Lew, MIAS, Contract Administrator, was named Vice-President in charge of Contract Administration, and Lynn D. Richardson was elected Vice-President in charge of Military Sales. Mr. Richardson is headquartered in Washington, D.C. . . .Theo A. (Ted) Wells is reported to have resigned as Vice-President and Chief Engineer of Beech last August.

• **Boeing Airplane Company. . .**Two new reconnaissance versions of the B-47 Stratojet are now being delivered to the USAF. One of these new models is the RB-47E, a day-or-night long-range photo ship. The other one is the RB-47B, a specially converted standard Stratojet bomber that can be used either as a photo-reconnaissance aircraft or as a front-line high-altitude medium bomber. . . .Two C-97 Stratofreighters have been taken from the assembly line at the Renton, Wash., plant and equipped with Pratt & Whitney T34 turboprop engines. Under a USAF contract, these two C-97's will work as service test aircraft for the T34. . . . The Boeing 247 transport known to countless persons in and out of the aeronautical profession as "Adaptable Annie" has been given a place in the National Air Museum. "Adaptable Annie" was the airplane used by Col. Roscoe Turner, Clyde Pangborn, and Reeder Nichols in the 1934 London-to-Melbourne air race. Following the Melbourne junket, she was in the service of United Air Lines, Inc., for 2 years. After that, she was turned over to Union Electric Company as an executive plane; she went into Government service in 1939, first, with the Air Safety Board and, later, with the CAA. CAA engineers converted her into some sort of a "flying guinea pig.". . . Edward C. Wells, AFIAS, Vice-President—Engineering, is now heading the recently formed Planning Committee. At the time of the above announcement, it was also stated that Mr. Wells's responsibilities had been redefined (1) to emphasize research and development work and (2) to include an analysis of customer requirements as a basis for future planning. Under this arrangement, Mr. Wells gives general policy direction to both engineering and sales function and is responsible directly to Boeing's President, William M. Allen.

• **Boeing Airplane Company and Flight Refueling, Inc. . . .**On September 2, a joint announcement was made by the USAF Air Research and Development Command, Boeing, and Flight Refueling stating that the preliminary phases of an aerial refueling project in which a converted B-47 Stratojet was used as a tanker aircraft had been completed. The system used in this project was an adaptation of the probe-drogue in-flight refueling method developed for the USAF in England by the British firm, Flight Refuelling, Ltd., whose United States affiliate is Flight Refueling, Inc. The modified B-47 used in this project can be converted under field operating conditions from a bomber to an aerial tanker and back again to a bomber as required. A slight modification for the refueling test was also required on the receiving airplane, another B-47. All production B-47's are equipped for in-flight refueling.

• **Brooks and Perkins, Inc. . . .**A new folder entitled *Magnesium Plate and Sheet To Reduce Weight* is now available from the Detroit office. This publication describes dimensions, tolerances, etc., of the different grades of products produced at its recently opened Rolling Mill in Detroit; it also devotes a page to comparing the gages required for equal stiffness in sheet magnesium, aluminum, brass, and steel.

• **The Cessna Aircraft Company. . .**The USAF recently took delivery on a turbo-

(*Continued on page 58*)

Editorial

Another "Mission Accomplished"

The Fourth International Aeronautical Conference with The Royal Aeronautical Society of Great Britain has come and gone. To report anything less than "an unqualified success" would be to shade the truth. Both societies were represented by large numbers of "top drawer" delegates. The papers presented were of high caliber. Discussions were lively and worth while. The University locale was appropriate and convenient, and the field trips were most interesting. Even the traditionally uncertain London weather was on its best behavior.

For one who looked objectively at the audiences of three previous conferences the large attendance at the Fourth provoked a particular feeling of satisfaction. When over 700 people can be brought together from all parts of the world for technical discussion of aeronautical subjects, the basic idea must be sound.

Nearly 150 American delegates (accompanied by some 50 wives and children) turned up in London during the proceedings. Notable was the British registration of over 500 RAeS members from all parts of the world. No accurate count was made, but it was obvious that a high percentage of those present this year had attended at least one prior conference. A great number (both British and American) had been present at all four.

We suspect that the Shell-Mex Oil Company was somewhat surprised by the size of the meeting. Early in the planning stages it had generously agreed to supply all the delegates with special "zipper" type portfolios to contain the voluminous conference paper work. As the registrations mounted, orders for the brief cases had to be increased several times. By Conference date, however, every delegate found one ready for him, tagged with his own name and beautifully embossed with the seals of the two societies. They literally blossomed out all over London—the hallmark of the Conference delegate. We heartily express our thanks and appreciation to Shell-Mex for this very real contribution to the event.

A special vote of thanks goes also to the University College of London for the excellent accommodations it provided for the meetings. Like Shell-Mex, its original planning had to be revised many times as the number of delegates grew. Lecture hall schedules had to be shifted practically at the last minute, and arrangements for food and entertainment facilities had to be expanded tremendously. Old Jeremy Bentham, one of the Founders, whose mummified remains are still on view in the University, must have been well pleased by the performance of his descendants.

There is little need to comment here on the caliber of the papers or of the authors. In opening the sessions, IAS President McCarthy pointed out that the authors and the papers were assumed to be good otherwise they would not have been selected, and he suggested that time for essentials could be saved by eliminating the conventional congratulatory remarks so dear to many discussers.

(Full texts of all papers were available to delegates on the opening day and will shortly be distributed by the RAeS in final form together with a transcript of all discussions.)

Our editorial "needling" of American delegates with respect to participation in discussions seemed to bear fruit. Not only did the regular "stand-bys" take part but many others of our group were frequently on their feet during discussion periods. British discussers still outnumbered us (which might be expected with a four to one attendance ratio) but the response was far better than it had been in Brighton in 1951.

Dr. Ballantyne and his staff are to be congratulated on the quality and on the management of the field trips. They put up a good show. They had a difficult problem in trying to fit all our requests into a period that was otherwise well crowded by S.B.A.C. events and a miscellany of technical conferences. All Americans who participated in group events were full of praise for the manner in which they were handled. We had little trouble this year with American "no shows." For the most part the embarrassment that we suffered in 1951 by last minute and unannounced changes in personal schedules was avoided. It will be remembered that on one unfortunate occasion 2 years ago only six Americans showed up for a day-long trip for which transportation, guides, food, etc., had been provided for the 40-odd who had originally signed up—this at a time when motor fuel was still scarce, and most foods were on ration.

We cannot let the occasion pass without some comment on current conditions in England. Those of us who remembered London in wartime know how grim it was. Things were not much better during the first Conference in 1947 (except that nothing lethal was falling out of the sky). In 1951 some improvement was in evidence, but many items were still rationed, shortages still existed, and things still looked a bit dull. This year, however, the change was striking. People looked better—better dressed, better fed—much happier. Store windows were full, rationing (for the most part) was over, and there were few shortages. Many buildings (not only in London where the effects of the Coronation had been felt but elsewhere) had been repaired and repainted. Most vehicles on the roads—cars, buses, trucks, and cycles—seemed shining and new. Only the railroads appeared to be lagging. Some main-line trains had been modernized, but the local and branch-line equipment seemed to be largely of the "Far Tottering and Oyster Creek" variety. Few were really clean; many were extremely dirty. Recent accident records indicate that operating and maintenance procedures are not what they should be. Nationalization apparently does not always work miracles.

But we should not wind up on even such a mildly critical note. The British are really wonderful! We cannot say too much for the hospitality and friendliness of our hosts. We are glad for them that general conditions of living are on the mend. The austerity of the past 15 years seems to be over. We only hope for them (and for us) that world conditions may never again degenerate to such levels. We are all convinced that, through the exchange of ideas and the better understanding of our common aims which results from Conferences such as ours, the hands of the free world will be so strengthened that devastating wars will be forever impossible. We look forward to many more such meetings.

S. P. J.

During the London Conference representatives of the Councils of the RAeS and the IAS met to discuss plans for the future. Subject to final confirmation by the Councils of both societies, the Fifth International Aeronautical Conference will be held in Los Angeles during the last 2 weeks of June, 1955. Present plan is to combine the International with our Annual Summer Meeting on the West Coast.

* * * *

The January, 1954, issue of the *REVIEW* will cover the technical aspects of the Conference. This delay in scheduling is necessary because the December, 1953, issue will be devoted to the 50th Anniversary of Powered Flight.

A New Space Rate Sensing Instrument

JOSEPH LYMAN*

Sperry Gyroscope Company†

We are privileged to publish two papers disclosing the first practical employment of a fundamental discovery derived from Leon Foucault's work in the 1850's. With all new discoveries the temptation is to predict the immediate wonders it will accomplish. In announcing the new Gyrotron® vibrating rate gyro, however, ***the authors caution that several more years of development may pass before the invention is refined for simple application.*** *(Ed.)*

ABSTRACT

The Sperry Gyrotron‡ angular tachometer is an instrument for securing a spatial reference signal through use of forces generated by oscillating mass motions. This paper treats in a qualitative manner the general principles involved in this new concept. Some of the factors essential to the design of a practical instrument are discussed. A second paper deals with quantitative details of a practical instrument.

INTRODUCTION

DURING RECENT YEARS, a new type of gyroscope has been under development at the laboratories of Sperry Gyroscope Company. This instrument, called by Sperry's proprietary name the Gyrotron angular tachometer, obtains its gyroscopic signals from a vibrating or oscillating mass instead of from the continuously rotating wheel supported on bearings employed in the usual gyroscope.

The instrument does not require bearings, since the motion is small and oscillatory in character.

(I) THE PRINCIPLE OF OPERATION

In order to understand the operating principles of this new instrument, an experiment will be described. If a structure like a vibrating tuning fork (Fig. 1) is firmly grasped by the handle and then turned rapidly about the vertical axis, an oscillatory twisting action will be felt. The amplitude of this twisting action is a direct measure of the rate at which turning takes place. The principles involved in this simple experiment are the bases for the design of an instrument for use as a spatial (inertial) reference signal source.

It is worth while to examine the experiment in more detail to discover some of the reasons for the observed action. First, let us look down on the tops of the tuning fork tines as shown in Fig. 1. We will see that at the instant of time shown, both tines are in the middle of their swing toward each other, but in the experiment the whole fork is being forced to turn in a counterclockwise direction. According to Newton's first law of motion,** the left-hand tine will assist the turning force and will exert a force through lever arm r_1 to cause the handle to twist. At the same time, the right-hand tine, which is moving in the opposite direction in space, will also assist the turning and will, therefore, provide an additional force linked through r_2 and will cause twist of the handle in the same direction as the force produced by the left-hand tine. These two forces, therefore, when transmitted down through the tines of the fork to the handle, both tend to add in such a direction as *to assist* the turning motion at this part of the cycle. It can be seen from the above that, when the tines of the fork make their *outward* swing away from each other, the forces will have opposite directions. The two forces then form a couple that alternately twists the handle.

Continued turning of the handle of the fork, therefore, will result in an oscillating torsional force in it, and this is the oscillation that would be felt by the experimenter. The amplitude of the oscillation is proportional to the rate of turn of the handle about its axis.

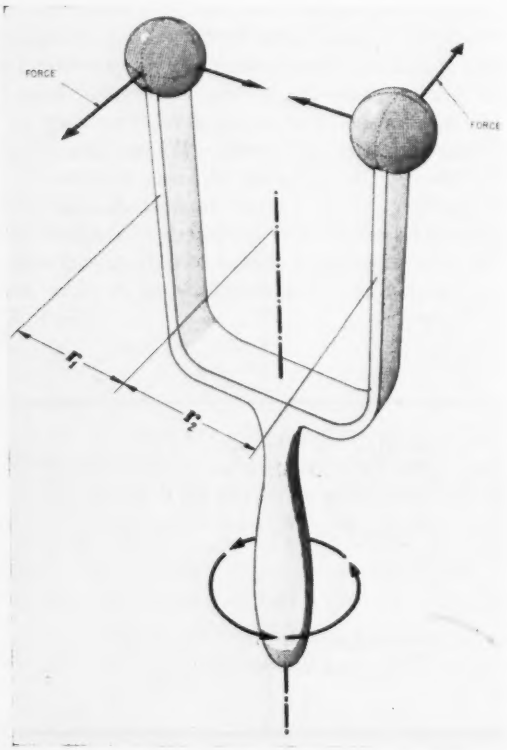


FIG. 1. Tuning fork. Fork with forces acting while tines are moving.

* Now with Airborne Instruments Laboratory, Inc.

† Division of The Sperry Corporation.

‡ Reg. U.S. Patent Office.

** "Every body remains in its condition of rest or of uniform motion in a straight line except if it is compelled to change that condition by external force applied to it."

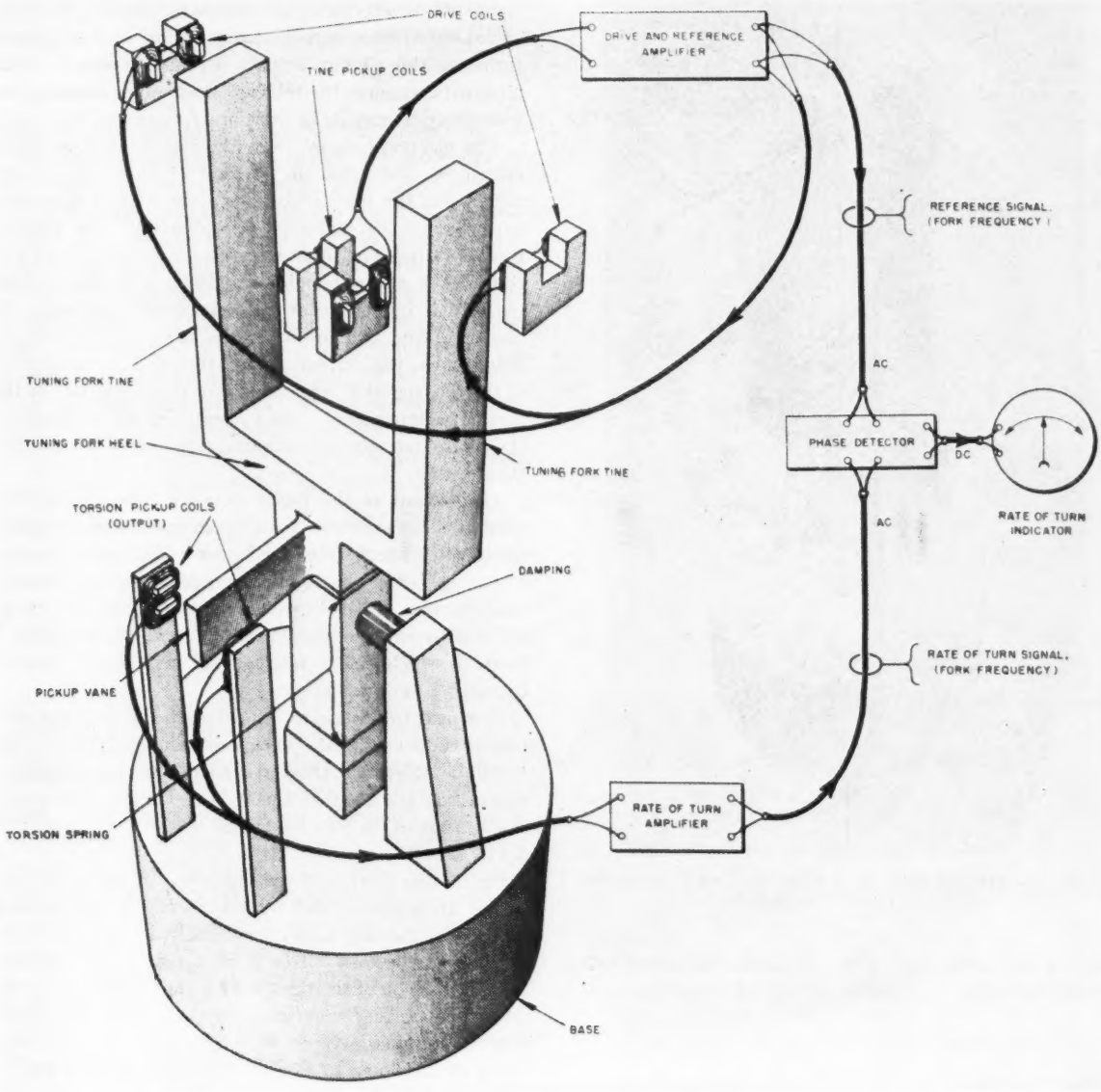


FIG. 2. Gyrotron schematic showing essential components.

To secure a useful signal that tells not only the angular velocity but also the direction of a turn requires that the twisting forces at the base of the fork be compared at any instant of time to the motion of the tines at that particular instant. Of course, this cannot be done in the simple experiment illustrated, but it will be shown that knowledge of the direction of tine motion for any moment will tell whether a clockwise or counterclockwise turn is being imparted.

For example, if, at the instant of time shown, the direction of the turning motion is changed from counterclockwise to clockwise, then all forces will reverse their direction. If we plot the resulting signals on a time base as in Fig. 6, we will see that there is a *180° phase difference* between signals resulting from a clockwise turn and signals resulting from a counterclockwise turn. The tuning fork, therefore, develops forces that will yield a knowledge not only of the *rate of change* but also of the *direction of change* of orientation of the surroundings and thus gives an inertial *spatial reference signal*. The signal is a measure of angular velocity or more commonly "rate of turn." The degree of precision with which these simple forces can be measured determines the usefulness of an instrument based on these principles.

It is next necessary to provide means for developing the output forces that are to be measured. A convenient arrangement is to use the supporting member for the fork as a resonant mechanical system. It will be recalled that the output forces are torsional—that is, they act through couples alternately to twist the handle. If a rod of the correct length to be resonant in *torsion* at the operating frequency is substituted for the handle and is placed between the heel of the fork and a base

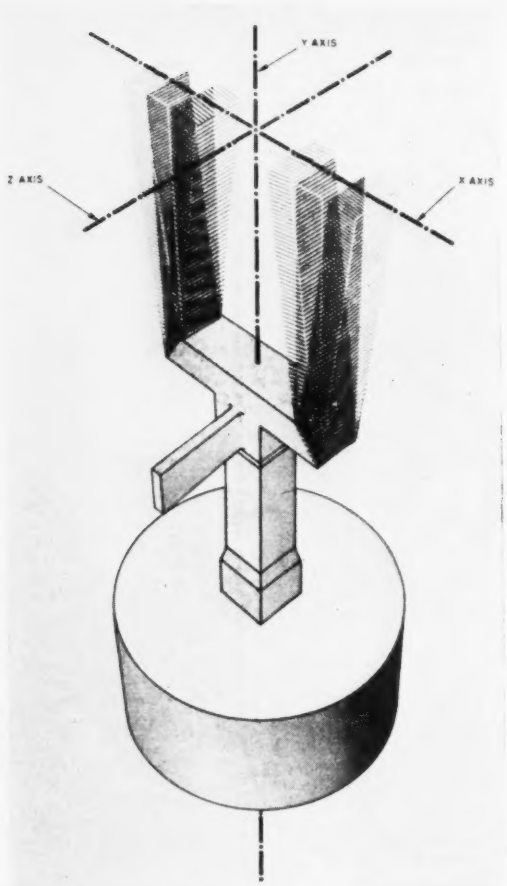


FIG. 3. The gyrotron axes. Fork vibration along X axis in the absence of rotation is illustrated.

plate of the instrument, then the oscillating forces will excite the rod at its resonant or natural frequency.

(II) The Operation of a Typical Instrument

Fig. 2 describes the basic elements of the instrument. In order to cause the fork to vibrate continuously and automatically, electrical pickup coils are inserted near the moving tips of the fork. The signal picked up by the tine pickup coils is amplified and used to drive the tines by means of magnetic attraction between the field of the drive coils and the fork tines. The fork will then oscillate at its natural frequency determined by the physical constants of the fork, such as shape, physical dimensions, type of material, etc. The pickup and drive coils merely supply energy lost during each cycle of the fork vibration in order to make it continuous at a constant amplitude.

The twisting action that the experimenter felt, using the instrument in Fig. 1, must now be detected in some other manner so that electrical signals proportional to the gyroscopic signals will be available. A vane attached to the heel of the fork oscillates in a transverse motion between the two magnetic pickup coils. The motion of the vane between the coils generates a signal that alternates at the fork frequency. This signal is amplified and compared to the amplified signal from the tine pickup coils in a phase detector. Such a circuit compares the relative phase angle between the two electrical signals of the same frequency.

The electrical signal from the pickup coils is determined in phase by the motion of the pickup vane relative to the torsion coils. In the case of the reference signal, the phase is determined by the relative motion of the fork tines with respect to the tine pickup coils. The phase detector supplies a d.c. signal whose polarity is indicative of the relationship between the phases of the two input signals, and, in this case, it determines the direction of turn. The amplitude of the d.c. signal is proportional to the amplitude of the torsion pickup signal. As a result, the d.c. signal from the phase detector tells the magnitude and direction of turn.

The output of the phase detector, then, is a direct current that varies ± through zero and is a direct measure of rate of turn. It may be used to actuate a meter, as in the figure, or may be arranged to actuate servomechanisms. A servomechanism may be used to drive the instrument itself to approach zero rate of turn as a limit, in which case a *displacement* instead of a rate of turn signal is derived.

It is next important to establish the axes of the motion of the instrument. These are illustrated in Fig. 3. It will be noted that the vertical axis through which the rate of turn is measured is called the Y axis. The plane of vibration of the fork tines is along the X axis, and the Z axis is at 90°.

Fig. 3 also illustrates symbolically the motion of the tines. In practice, and by means of the mechanical design, the moving mass is essentially a hinge action at the heel of the fork. It will be noted by the shading that the motion of the tines is such that they both move toward each other simultaneously and away from each other simultaneously.

Let us now turn to Fig. 4, which is similar to Fig. 3 except that the base of the device is now under a condition of continuous clockwise rotation. It will be noted that, as the tines move from position "a" to position "c," a torsional twist appears in the supporting column and torsion spring of the fork. This is shown in exaggerated form in Fig. 4. Note in the two small diagrams of Fig. 4 at the bottom left- and right-hand corners that, when the tines are in position "a," the pickoff vane is shown adjacent to the right torsion pickup coil. Position "c" of the tines shows the pickup vane adjacent to the left torsion pickup coil.

Fig. 5 is similar to Fig. 4 except that the base of the instrument is now rotating continuously at a constant rate and in a counterclockwise direction. If, now, tines at position "a" are noted, it will be seen that the pickup coil is the opposite of Fig. 4. By further comparing Figs. 4 and 5, it will become apparent how the direction of rotation changes the time relationship of the tines and the pickup vane. All forces change their direction from clockwise to counterclockwise, with a result that

the electrical phase relationships from the pickup coils also change their direction. There is, therefore, 180° electrical phase difference between a clockwise signal and a counterclockwise signal.

Both the mechanical and electrical effects are shown related to each other in Fig. 6. The motions shown in Figs. 4 and 5 have been plotted on a time scale in their normal sequence. For example, five discrete positions are shown for the tine motion and the resultant pickup vane motion for one cycle in a clockwise turn. These same relations are plotted directly below for a counterclockwise turn. The tine motion, of course, is smooth and continuous, and the plot merely illustrates discrete intervals of time during one complete cycle. It will be noted that the electrical phase signal has reversed its polarity from the clockwise to the counterclockwise turn. It will also be noted that amplitude of the electrical signal increases with increased rate of turn.

Fig. 7 is a photograph of a model instrument for demonstrating the principle of operation. The schematic of Fig. 2 applies to this instrument.

(III) Practical Considerations in the Design of a Useful Instrument

(A) The significant factors in the design of such an instrument are as follows.

(*1*) *Drive*

The two masses must be driven toward and away from each other without imparting side coercive forces of such a nature as to be transmitted through the mechanical output circuit. Furthermore, the motion should closely conform to a pure sine wave so as to generate the least harmonics.

(*2*) *The Fork*

It has been found practical to use the tines of a fork as the masses and to support the fork on the output mechanical circuit. The design of the tines imposes new considerations beyond those normally encountered in the acoustical case, where high "Q" and invariable frequency are the basic considerations. In the case of a gyroscopic vibrator neither of these considerations is of fundamental importance. What is required is stability of the character of motion of the tines themselves. This implies that it is necessary to prevent distortion of the structure due to temperature change or aging effects. Suitable materials are usually those with small thermal coefficients of expansion and elasticity.

(*3*) *The Arcuate Motion of the Tines*

In the ideal case, the moving masses are required to operate on straight lines, but, in the practical cases of the fork, the motion is through an arc whose center of radius is near the heel of the fork. The vertical component of this motion is undesirable since it contributes an unwanted vertical coupling signal to the output circuit. Therefore, its effects should be minimized.

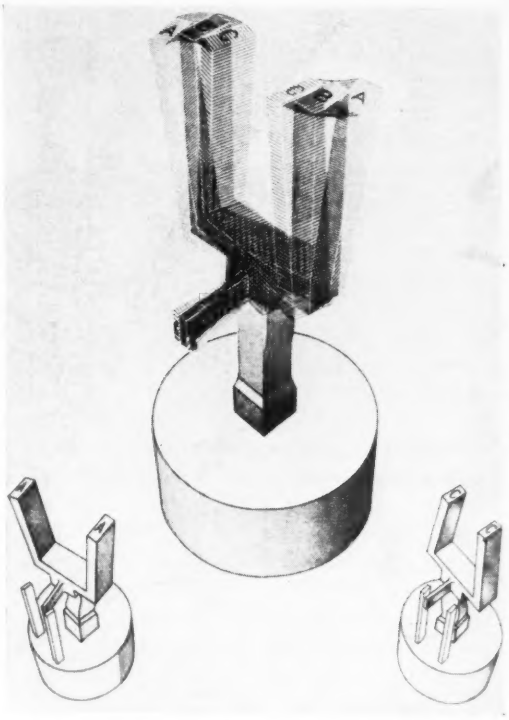


Fig. 4. Clockwise rotation. The motions of the mechanical elements in the presence of clockwise rotation of the whole structure about the Y axis.

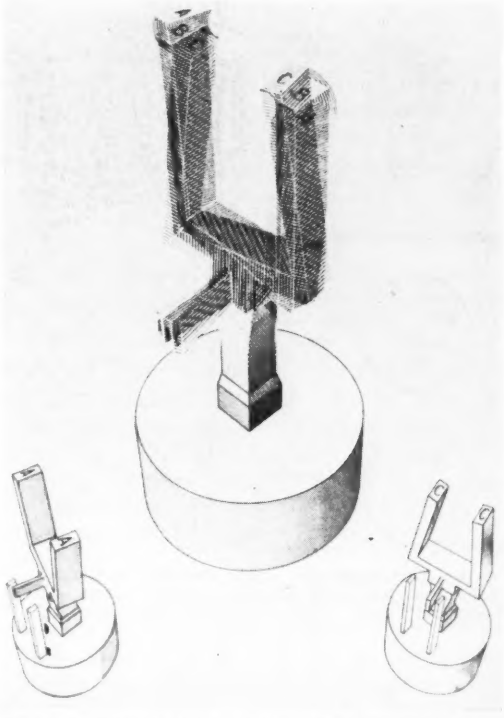


Fig. 5. Counterclockwise rotation. The motions of the mechanical elements in the presence of counterclockwise rotation of the whole structure about the Y axis.

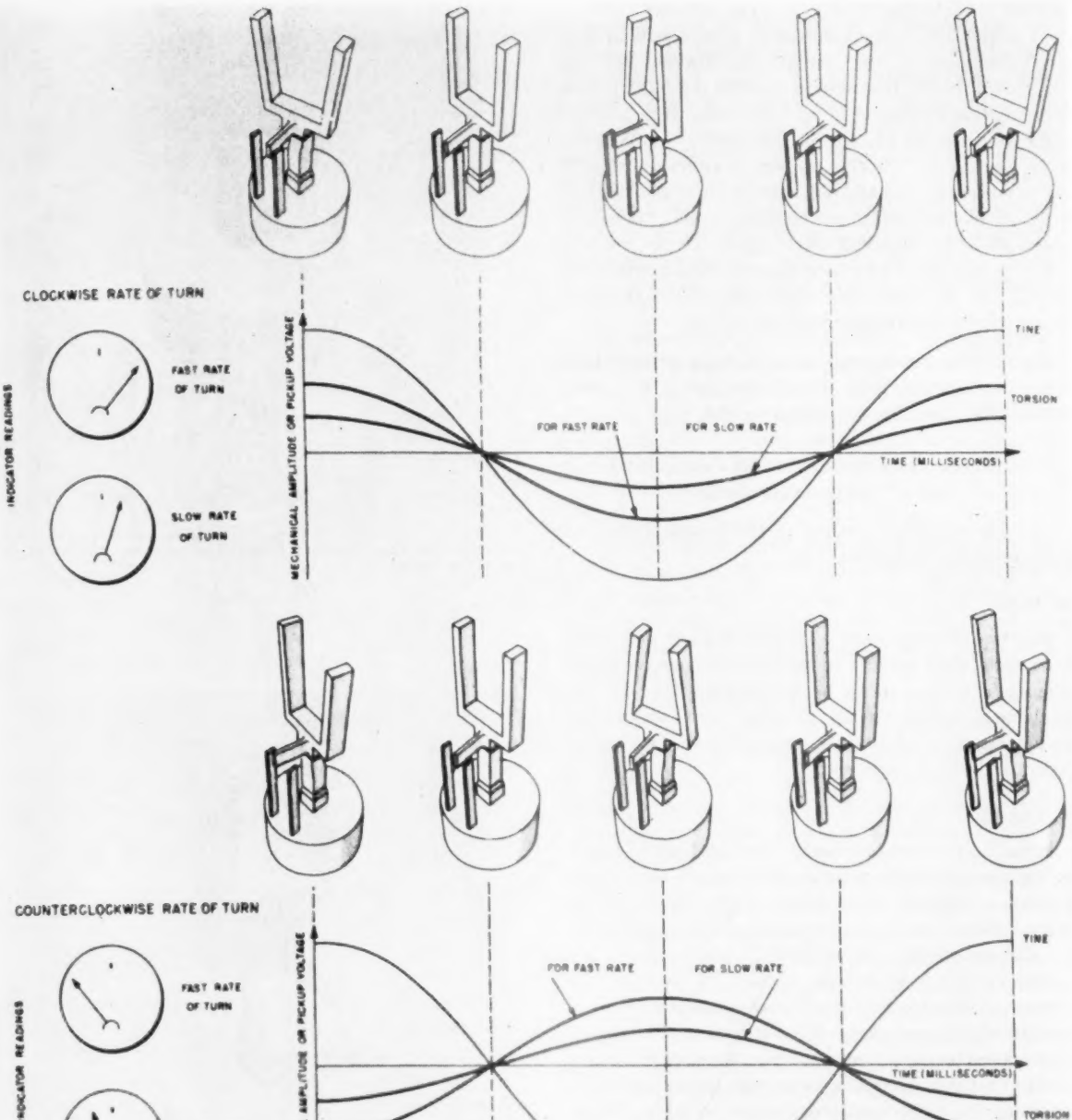


FIG. 6. Time sequence. (Note that the illustrations of the deflection of the fork are "instantaneous photographs" corresponding to discrete time intervals along the sine curves.) Resulting mechanical motions and/or pickup voltages produced by rotation—plotted against time. Indicator readings also shown.

(4) Control of Lateral Resonances

The tines of the fork may vibrate as a whole laterally in the plane of the tines or at right angles to it. Control of these lateral vibrations is of great importance since they can give rise to unwanted signals. Either effect can commonly be minimized by mass balancing of the tines in somewhat the same manner as is done with gyroscopic rotors. Such balancing can be controlled with precision and is invariable.

(5) Environment

The vibrations of the fork tines may be affected by the external environment such as coupling to external vibrations and stray magnetic fields. The effects of external vibrations are usually readily controlled by a suitable nodal support and by isolation mounts. In the case of a fork made entirely of magnetic material, it is necessary to provide shielding if the instrument is to operate in the presence of large stray magnetic fields.

(6) Electrical Coupling Between X and Y Axis

Electrical coupling between these two circuits, if constant, merely introduces problems of distortion and overload. It is readily possible by the proper choice of drive and pickup coils, by shielding, and by care in the use of nonmagnetic materials to reduce the coupling to a negligible value.

(7) The Output Signal Pickup

Since the vibration, which is a measure of rate of turn, is in a torsional mode, it is desirable to form a couple to actuate a linear type of electromagnetic pickup. This pickup must be designed to extract the maximum amount of energy from the output mechanical circuit. It is usually desirable to withdraw as much energy as possible through the pickup circuit in order to achieve maximum efficiency. The higher the efficiency of the conversion circuit or electromechanical transducer, the greater the possibility of achieving a low noise factor, or conversely, the less stringent are the requirements on the output amplifier.

(8) Damping

There is a considerable variety of means to secure damping. The one most commonly employed is to use viscous damping as illustrated in Fig. 2. Here, plastic pads are caused to bear on and restrict the speed of motion of the torsion system. The net effect is to flatten the response curve of the mechanical output circuit, which implies that a reduction in sensitivity will result since the amplitude of motion is necessarily decreased for a given impressed rate of turn signal.

(9) Zero Signal

The principle upon which the instrument is based requires that there be zero coupling between the input and output axes in the absence of rotation. In practice, such a condition is difficult to achieve, and there will usually be some signal coupled between these two axes. Therefore, every attempt should be made to remove the effect of this residual signal.

FIG. 7. Photograph of demonstration model.

(10) Time Constant

Knowing the torsional "Q" and the operating frequency, the time constant of the whole instrument may be calculated. In practical instruments, the response to a step function may be adjusted to a wide variety of requirements.

(11) Stability

The stability of the instrument is governed by the degree of variableness of the factors previously listed. The absence of any frictional factors contributes to high stability. The primary factor of importance is the degree of balance which may be achieved.

(12) The Sensitivity

The sensitivity of the instrument is fundamentally related to the bandwidth of the entire output circuit (mechanical and electrical). The usable sensitivity is related primarily to the basic stability. The upper limit should be reached when amplifier gains employed give a signal sufficient to be obscured by thermal noise.

(13) Noise Factor

Since the instrument has no bearings, there is no contribution to noise from this source. Noise due to windage and other atmospheric effects can most conveniently be avoided by operating the instrument in a vacuum. Noise arising from external sources may be reduced to negligible proportions by proper choice of operating frequency and normal care in the design of the isolation mounting.

(14) Linearity

An important characteristic of an instrument of the character described is the range of sensitivity over which the output signal is linear. Due to the fact that the output forces are alternating, problems of hysteresis uncertainty are avoided. As a result, it is possible to operate over an extended range of linear response to rate of turn. To secure linearity, it is also neces-

sary to ensure a controlled constant amplitude. At the higher rates of turn, linearity would be destroyed if constant power instead of constant amplitude were applied. This situation arises from the fact that the output energy is energy derived from the tine motion itself; therefore, if appreciable energy is withdrawn from the output circuit, as will be the case at high rates of turn, the result will be decreased amplitude of tine motion and, hence, reduced signal output. For linearity considerations, therefore, the amplifier must be designed to resupply the required amount of energy.

(15) *Amplifier Characteristics*

Considerations in the design of the output amplifier are such as to impose no unusual requirements. This situation exists because the a.c. signal from the Y axis pickup coils can normally be made large. This signal (usually expressed in volts per degree per hour) then requires an a.c. amplifier of relatively low gain.

Drive amplifier requirements consist mainly in providing a drive voltage sufficient to maintain tine oscillation at constant amplitude. The degree to which this is accomplished determines the overall linearity of the instrument.

(16) *Effects of Acceleration*

Because of the possibility of using essentially unitary construction and because of the overall stiffness of the whole structure, the instrument may be designed to withstand accelerations of large magnitude.

(17) *Effects of Off-Axis Rotation*

All rotations on axes other than the sensitive axis will give essentially zero output. This is true because the mechanism by which a rotation about an unwanted axis can couple into the sensitive axis is a process that requires an unbalance in the tines themselves. Normal balancing procedure reduces such possible unbalances to negligible values.

(18) *Modulated Moment of Inertia*

Detailed examination of an oscillating fork will show that only that portion of the total mass of the fork which is in motion laterally is available to yield the output signal. Consequently, all masses on the output axis which are not in lateral oscillation will contribute nothing to the desired signal. Therefore, in the design of a practical instrument, it is necessary to secure the highest degree of *modulated* inertia if high efficiency is required.

The above statements imply that the original concept based on Newton's first law of motion is not the only way of describing the operation of an instrument of this type. It is possible to regard the device as a system of moving masses in which the speed of rotation of the fork about its axis is increased relative to the impressed rate of turn when the tines are moving toward each other. This is so because in this case, in order for the law of conservation of momentum* to apply, the rotation must speed up to act for the reduction in the radius of the mass motion. Conversely, when the tines are moving outward, they are increasing their radius of gyration; therefore, to conserve momentum of the system, the whole fork is forced to slow down its turning with respect to the base structure of the instrument.

These characteristics are related as indicated in the following formulas.

$$\begin{aligned} I &= M(R_0 + \Delta R \cos 2\pi ft)^2 \\ &\cong MR_0^2[1 + (2\Delta R/R_0) \cos 2\pi ft] \\ &= I_0[1 + (2\Delta R/R_0) \cos 2\pi ft] \end{aligned}$$

where

I = instantaneous inertia
M = mass of entire system
R_0 = average radius of gyration
ΔR = maximum change in radius of gyration
I_0 = average rotational inertia
f = tuning fork frequency
t = time

(IV) Conclusion

Because of the absence of bearings, the rate of turn instrument described is fundamentally a low noise signal source for spatial reference.

* "The total angular momentum of any system of bodies is unchanged by actions within that system."

Suggestion for Binding
Issues of the Aeronautical Engineering Review

Arrangements have been made so that our readers may have their issues of the Review bound carefully and economically in our authorized binding. Simply write for details to:

AIRE
P.O. Box 776
Highland Park, Illinois

General Theory and Operational Characteristics of the Gyrotron* Angular Rate Tachometer†

ROLAND E. BARNABY,‡ JOHN B. CHATTERTON,‡ and FRED H. GERRING**
Sperry Gyroscope Company and Bureau of Aeronautics

ABSTRACT

The Gyrotron angular rate tachometer presents problems not generally met in the development of the older and more commonly used gyroscopic devices. The operation of the device depends upon acceleration forces that are developed by a vibrating mass when it is subjected to a change in direction of motion. In this paper, the theory of the Gyrotron angular rate tachometer is reviewed in detail, and a discussion of operational characteristics, design details, and applications is given. In a companion paper (see page 24 of this issue), Joseph Lyman further discusses the operational features of the device. **Observe also authors' cautionary note.**

INTRODUCTION

THE GYROTRON ANGULAR RATE TACHOMETER, a development of Sperry Gyroscope Company, uses a new approach to the problem of measuring angular rate relative to fixed space. If a vibrating mass is rotated about a specified axis, forces that are alternating in nature will be set up. These forces may be used to develop a signal voltage output that is proportional to angular rate.

Historically, a device of this nature is not without precedent. The early work of Foucault included a series of experiments on vibrating reference devices, the most famous of which is the Foucault pendulum. This work actually preceded his better known invention, the gyroscope.

In principle, the Gyrotron angular rate tachometer is analogous to the Foucault pendulum. It differs in the major respect that the vibrating mass is elastically constrained to rotate with the supporting structure. The signal voltage is developed from an alternating force that is set up during each cycle of vibration under an applied rate of turn.

High-performance military equipment has placed many new demands on instrumentation of the inertial reference type, and the demands of modern aircraft have been particularly great. The instrumentation must not only respond to rapidly varying changes in attitude but, in addition, it must be capable of full maneuverability and long-term navigational accuracy. These are characteristics that can be demonstrated by the Gyrotron angular rate tachometer.

PRINCIPLES OF OPERATION

The Gyrotron angular rate tachometer utilizes a vibrating system composed of two identical masses, driven magnetically in opposition in the same plane with equal amplitudes. The general requirements for these vibrating masses are realized in a forklike structure, similar to the common tuning fork, as shown in Fig. 1. The operation of the instrument depends on the vibration of the fork tines much the same as a gyroscope is dependent on the rotation of a wheel. A fundamental difference is that under dynamic conditions the rotating wheel develops a steady torque whereas the fork, because of the periodic change in direction of motion of the tines, develops an alternating torque. This alternating torque is measured as a voltage developed by an electrical pickup suitably located at the base of the fork. The magnitude of the signal is proportional to applied rate of turn, and its direction is determined by the phase of the developed signal relative to the fork motion, there being a 180 deg. phase difference with change in direction. A more detailed discussion of operational theory is presented later.

The pickup used to detect rate of turn may be any of the general types of transducers, depending on the application requirements. In the illustration (Fig. 1), a conventional variable reluctance type of pickup is shown. It is mounted at the base or frame of the instrument and is sensitive to the differential velocity of the heel or bottom of the fork with respect to the frame. A pair of diametrically opposed vanes, attached to the fork heels, constitutes a return path for the magnetic pickup and a lever arm for amplification of the developed motion. Upon application of a rate of turn component about the central axis of the fork, the resulting oscillating motion of the fork heel varies the pickup air gap and produces an output proportional in amplitude to the rate of turn. The alternating signal thus developed may be amplified and utilized directly, or, if a direct current output is desired, it may be compared to a reference signal in a phase-detecting and demodulating circuit.

Response of the instrument to a rate of turn is limited to one axis. This axis is located along the centerline of the fork and torsion spring. Large acceleration forces about or along other axes could produce uniform bending of the fork and may possibly produce a transient, but in no case will there be a sustained vibrational coupling that could be interpreted as a rate of turn.

---

* Reg. U.S. Patent Office.

† Acknowledgment is made to the important contribution to both theory and practice by Dr. Charles T. Morrow, formerly with Sperry.

‡ Flight Instrument Engineering, Sperry.

** Electronics Division, Bureau of Aeronautics.

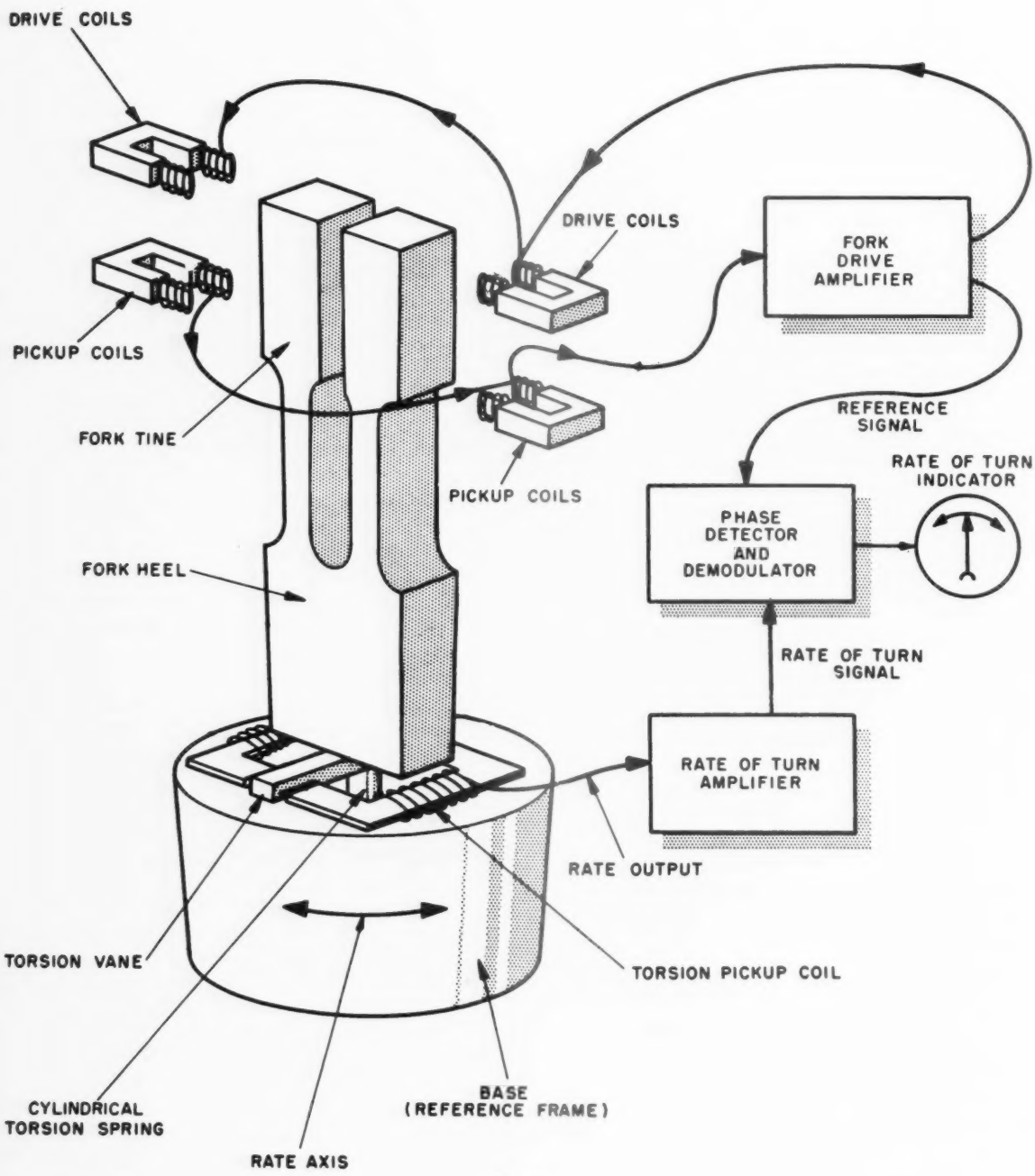

DRIVE COILS
DRIVE COILS
FORK DRIVE AMPLIFIER
PICKUP COILS
FORK TINE
REFERENCE SIGNAL
RATE OF TURN INDICATOR
PICKUP COILS
PHASE DETECTOR AND DEMODULATOR
FORK HEEL
RATE OF TURN SIGNAL
RATE OF TURN AMPLIFIER
RATE OUTPUT
TORSION VANE
TORSION PICKUP COIL
CYLINDRICAL TORSION SPRING
BASE (REFERENCE FRAME)
RATE AXIS

FIG. 1.

The fork vibration frequency, which determines the frequency of the rate output voltage, is chosen in the upper audio range. In this range, rapid response to applied rates becomes simpler to attain. Also, the choice of a high frequency permits greater isolation from the surroundings, with minimum time delays resulting from the mounting means.

The alternating force developed from the vibrating fork is a direct function of applied rate of turn about the sensing axis, and, assuming that the fork amplitude of motion remains constant, the signal developed at the pickup coils is also a direct function of applied rate of turn. For large rates of turn, some energy is extracted from the vibrating fork tines, and, in order to retain output linearity, it is necessary to make up the loss by applying additional energy to the coils driving the fork. In practice, a simple fork drive amplifier is sufficient to cover most of the range with negligible loss in linearity. There are no other elements in the instrument which affect signal linearity appreciably.

Loss in energy in the torsion spring is negligible, and damping must be applied about the rate axis to achieve a favorable time constant. This can be accomplished by a number of standard methods depending on design requirements.

Inertial forces developed under an applied rate of turn do not pass through bearings of any type before they are interpreted in the form of an electrical output signal. This elimination of a potential noise source, together with the inherently low noise level of the vibrating masses, makes possible a wide range of rate measurement. A range of one million to one in measuring rate of turning is well within the performance characteristics of this instrument.

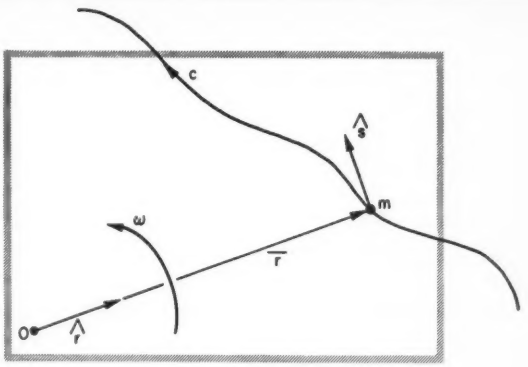


FIG. 2.

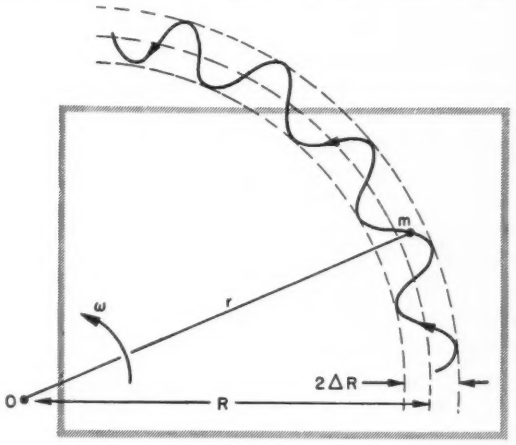


FIG. 3.

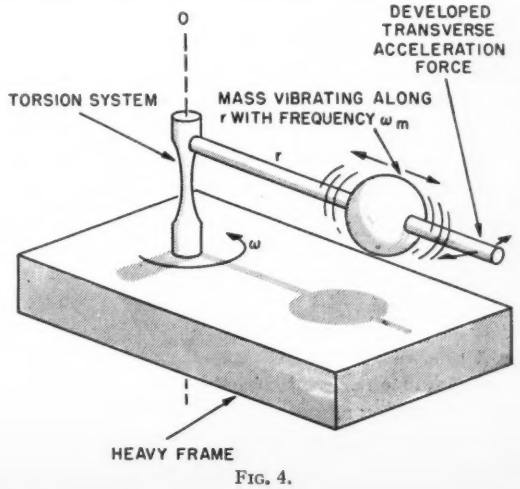


FIG. 4.

THEORY OF OPERATION

Consider a particle of mass, m, moving in a plane along some path, c, as shown in Fig. 2. Relative to point 0 in the plane, the motion may be expressed in terms of its radial and transverse resolutes, where $\hat{r}$ and $\hat{s}$ are unit vectors parallel and perpendicular, respectively, to the mass position vector, $\bar{r}$. The usual vectorial expression for the acceleration of m is,

$$\bar{a} = \left(\frac{d^2r}{dt^2} - r\omega^2\right)\hat{r} + \left(r\frac{d\omega}{dt} + 2\omega\frac{dr}{dt}\right)\hat{s} \qquad (1)$$

where ω is the angular velocity of $\bar{r}$. The right-hand side of Eq. (1) shows the radial, centripetal, angular, and Coriolis accelerations, respectively.

For reasons that will become apparent, it is desirable to show the reaction torque, $\bar{T}$, about 0, which could be produced by the acceleration force, $\bar{F}$, on m. Thus,

$$\bar{T} = -r\hat{r} \times \bar{F}$$

and, since $\bar{F} = m\,\bar{a}$,

$$\bar{T} = -m\left(r^2\frac{d\omega}{dt} + 2r\omega\frac{dr}{dt}\right)(\hat{r} \times \hat{s})$$

the magnitude of $\bar{T}$ being

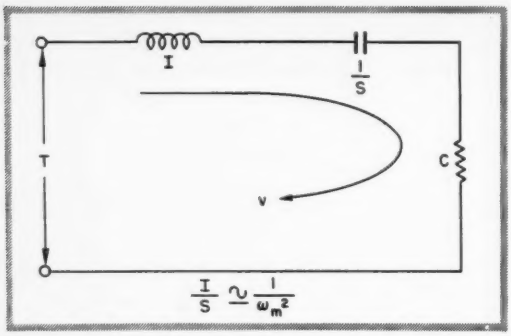


FIG. 5.

$$T = mr^2\,(d\omega/dt) + 2mr\omega\,(dr/dt) \qquad (2)$$

Since Eq. (1) is valid for a secondary inertial system, it will be shown that, by discriminating against the radial and centripetal acceleration forces in obtaining the torque of Eq. (2), a system can be obtained whereby the measure of the value of this torque with respect to a moving frame will be a measure of angular velocity of the system or frame with respect to fixed space.

If m is vibrated at a frequency, ω_m, in the radial direction and the mean distance from 0 held constant as in Fig. 3 so that

$$r = R + \Delta R \sin \omega_m t \qquad (3)$$

and

$$dr/dt = \Delta R\omega_m \cos \omega_m t$$

and if, for the time being, the angular acceleration term of Eq. (2) is dropped, Eq. (2) becomes

$$T = 2m\omega\,(R + \Delta R \sin \omega_m t)\,(\Delta R\omega_m \cos \omega_m t) \qquad (4)$$

or

$$T = 2m\omega R\left[\Delta R\omega_m \cos \omega_m t + \frac{(\Delta R)^2}{2R}\,\omega_m \sin 2\omega_m t\right] \qquad (5)$$

And, since

$$R \gg \Delta R$$

then,

$$T \simeq 2m\omega R\Delta R\omega_m \cos \omega_m t \qquad (6)$$

If an angular velocity of frequency ω_0, normally lower than ω_m, of amplitude Ω is applied so that

$$\omega = \Omega \cos \omega_0 t \qquad (7)$$

Eq. (6) becomes

$$T = 2mR\Delta R\omega_m\Omega \cos \omega_m t \cos \omega_0 t$$

or

$$T = mR\Delta R\omega_m\Omega\,[\cos\,(\omega_m + \omega_0)\,t + \cos\,(\omega_m - \omega_0)t] \qquad (8)$$

It is seen from this result that the available torque is a suppressed-carrier, amplitude-modulated force centered at the frequency with which the mass particle is vibrating.

If the particle of mass (Fig. 4) is held on a laterally rigid arm, r, which is supported at 0 through a torsionally coupled system to a frame of large mass, the torque of Eq. (8) will appear between this torsional support and the frame. In Fig. 4, the mass is vibrating radially along r and in a plane parallel to the frame and perpendicular to an axis through 0 which will contain the torque vector and will be the axis of angular velocity sensitivity.

If the torsional support is tuned to the frequency, ω_m, and contains torsional stiffness, s, damping resistance, c, and a total torsional inertia, I, the equation for the angular velocity, V, of the torsion system becomes analogous to the current of the series circuit of Fig. 5.

If arithmetic symmetry of the response of Fig. 5 is assumed—namely that

$$\frac{\omega_m + \omega_0}{\omega_m} - \frac{\omega_m}{\omega_m + \omega_0} \simeq 2\,\frac{\omega_0}{\omega_m} = K$$

the solution for the velocity is

$$v = \frac{mR\Delta R\omega_m\Omega}{c\sqrt{1 + Q^2K^2}} \times \{\cos\,[(\omega_m + \omega_0)\,t - \theta] + \cos\,[(\omega_m - \omega_0)\,t + \theta]\} \qquad (9)$$

where the torsion Q is

$$Q = (\omega_m I/c) = (s/\omega_m c)$$

and

$$\theta = \tan^{-1} QK$$

Rearranging Eq. (9),

$$v = \frac{2mR\Delta R\omega_m\Omega}{c\sqrt{1 + Q^2K^2}}\,[\cos\,(\omega_0 t - \theta) \cos \omega_m t] \qquad (10)$$

This shows the velocity of the torsion system with respect to its frame to be a direct function of the applied angular velocity of the frame with respect to inertial space.

Any type of electrical pickup could be used to sense the torsion motion to make a practical rate measuring device. The usual phase detection operation on the output signal will eliminate the cos $\omega_m t$ factor giving a final output with a polarity that will depend on the sign of Ω, the direction of the applied rate of turn. The output response is seen to be a function of the response of the torsion system, and damping its motion shortens the response time of the instrument. This response time is twice the response time of the torsion system because of the nature of the double side-band transmission.

It is seen that torques from the mass will result in extremely small torsion system motions, because of tuning, if their frequencies are much removed from ω_m. This helps justify the approximation made in Eq. (6). If the angular acceleration term, dropped from Eq. (4), is now considered, we can superpose the result and add any error to Eq. (10). The angular acceleration term, T_a, was seen to be

$$T_a = mr^2(d\omega/dt)$$

Substituting from Eqs. (3) and (7),

$$T_a = -m\omega_0\Omega \sin \omega_0 t \, (R + \Delta R \sin \omega_m t)^2$$

or

$$T_a = -m\omega_0\Omega \, [R^2 + (\Delta R^2/2)] \sin \omega_0 t + m \, (\Delta R^2/4) \, \omega_0\Omega \, [\sin (2\omega_m t + \omega_0) \, t - \sin (2\omega_m - \omega_0)t] - mR \, R\omega_0\Omega \, [\cos (\omega_m + \omega_0) \, t - \cos (\omega_m - \omega_0)t]$$

Approximating as before by dropping any term whose frequency is removed from ω_m,

$$T_a \simeq mR\Delta R\omega_0\Omega \, [\cos (\omega_m - \omega_0) \, t - \cos (\omega_m + \omega_0)t]$$

Comparing this result with Eq. (8), it is seen that the amplitude ratio is

$$T_a/T = \omega_0/\omega_m$$

This normally would be extremely small. The maximum value would depend on the response or maximum ω_0 for which the instrument is designed. (Applied velocities of higher frequency than this value would normally be attenuated by isolation supports or shock mounts between the frame and the moving vehicle. It would be important to keep spurious vibrations near the frequency of ω_0 from being transmitted to the frame regardless of this acceleration error.) It is seen that the higher frequency side band is negative and the lower positive. This tends to increase the slight error in the assumption of arithmetic symmetry of the torsion system response of Fig. 5. Nevertheless, Eq. (10) will be a very good approximation.

There is another second-order effect present in the type of system described. In addition to the applied input velocity, the mass also will contain the output velocity of the torsion system since the common coupling is rigid in the transverse direction. If the output velocity of Eq. (10) is assumed to be correct and is added to the applied input velocity of Eq. (7), repeating the derivations will show the error to be negligibly small.

In general, the derivations may be summed as follows. If a mass possesses a controlled oscillatory radial acceleration at a fixed mean distance from an axis (the plane of vibration being perpendicular to the axis), the transverse acceleration of the mass in the plane, at frequencies near the frequency of the vibrating mass, will be proportional to the inertial angular velocity of the system about the axis. The output acceleration will be modulated at the mass frequency, which should be higher than the frequencies of applied velocity. It is seen that the system of Fig. 4 is but one method of observing this transverse acceleration that is essentially the Coriolis acceleration.

Development Status and Design

The most important aspect of the design of the sensing element (Figs. 1 and 6) is the fork structure. The forces developed in the torsion spring under a rate of turn are small by comparison to those available from a gyroscope rotor, and a considerable amount of care must be exercised in reducing spurious vibrations caused by dynamic unbalance in the structure. Under idealized conditions, the masses, as represented by the fork tines, should vibrate in the same plane with equal amplitude and in exact phase opposition. The plane of vibration should also be coincident with the axis of mass symmetry of the entire structure. Achieving this condition is beyond the scope of ordinary machining tolerances of the individual parts and requires appropriate mass and stiffness correction of the vibrating members after assembly of the instrument. Balance however, while necessary for low uncertainties and a high signal-to-noise ratio, has no effect on useful life. The reduced section of the fork tines (shown in Figs. 1 and 6) reduces harmonics in fork motion and causes the unbalance forces to be more nearly sinusoidal. Such action makes it possible to measure and reduce the unbalanced condition. Once the fork balance has been achieved, it normally remains invariant for the life of the instrument. Selection of a suitable material for the fork is made on the basis of low expansion and stiffness change with temperature. Both these characteristics are important to obtain structural symmetry under conditions of varying temperature. By careful consideration of all the above-mentioned factors, it is possible to achieve an extremely favorable signal-to-noise ratio in the rate signal and outputs of low uncertainty.

The rate signal forces developed from the fork must be related to a fixed base or reference frame. In the instrument illustrated in Fig. 1, a cylindrical member connects the fork to its base. The torsional stiffness of this member is chosen to achieve a resonant frequency about the principal axis equal to the frequency of the vibrating fork. The axis of the torque developed from the vibrating mass, when an angular velocity is applied to the system, is coincident with the axis of the tuned torsion spring member. The rate signal then is conveniently measured as a function of velocity of this torsion member. Damping is applied to obtain a bandwidth and time constant suitable for a given application.

The Gyrotron angular rate tachometer is relatively resistant to damage due to shock and vibration. Structural components can be made so that the effects of large acceleration forces in any direction will be well within their strength limits. Once assembled and sealed in a hermetic enclosure, there are no occasions that require disassembly. The fork and the torsion spring, the only moving elements in the instrument, are operated well below their fatigue endurance limits, consequently their life expectancy is exceptionally long. Other static components, such as drive and rate pickup coils, are conservatively rated electrically and, since they are enclosed in the same hermetically sealed housing as the vibrating fork, are also free from maintenance problems.

The dynamics of the Gyrotron angular rate tachometer differ from those of the stan dard gyroscope in man

ways. Where a high rotational velocity is necessary in a gyroscope to achieve forces large by comparison to the retarding frictional forces of supporting bearings, the Gyrotron angular rate tachometer, having no bearings and developing a signal that periodically reverses polarity each cycle, requires only sufficient force to excite the tuned torsion spring. There is no uncertainty threshold (analogous to bearing coulomb friction that normally limits sensitivity of gyroscopic devices), and, hence, the minimum detectable rate that may be measured is solely a function of signal stability.

The physical size of the instrument can be subminiaturized with no loss in sensitivity, depending solely on the practical limitations of mass and force utilization. The theory of this subminiaturization requires a more advanced design analysis and indicates that size may be reduced without sacrifice of performance.

Instruments currently under investigation are shown in Figs. 6 and 7. The relative size of a sensing element that was developed for applications requiring moderate stabilities is shown in Fig. 6. The Gyrotron sensing element and amplifier in packaged form are shown in Fig. 7. In practice, the ultimate size of the instrument probably will be determined by manufacturing limitations. Indications are that sizes will be more than competitive with instruments offering similar performance characteristics.

FIG. 6.

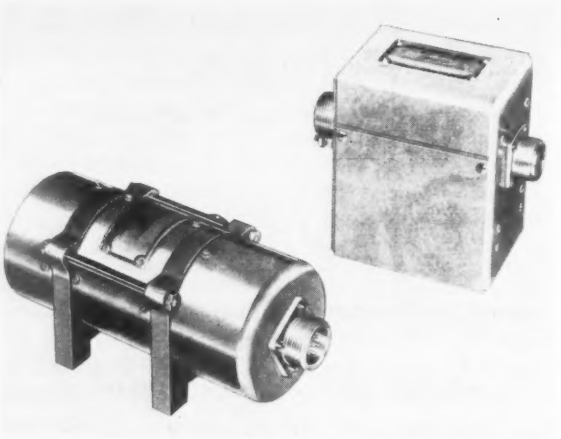


FIG. 7.

FUTURE APPLICATION

The Gyrotron angular rate tachometer is capable of application along two lines. First, through refinements to the sensing element, a rate signal of sufficient accuracy may be provided which will furnish a reference source for long-term navigation. Second, in applications where extreme sensitivity and stability may not be required, it is possible to utilize the other basic features such as ruggedness, fast response, wide dynamic range, and long life to advantage.

For applications that now fall within the scope of the standard rate gyroscope, the present instrument can be a relatively simple and compact instrument requiring little electrical power to operate. Although current plans include the utilization of electron tube amplifiers, it is possible that nonvacuum-tube types of amplifiers may be employed wherever necessary in the future.

The most interesting and important aspect of the future development program may be concerned with increasing signal stability and sensitivity to a level suitable for use directly as a long-term navigational reference. Results of the investigations made to date have not indicated any insurmountable theoretical problems that would place a limit on stability and sensitivity. It appears likely that further refinements of the known parameters will place the instrument in the class of high-performance displacement gyroscopes.

CONCLUSION

It is expected that in the near future the Gyrotron angular rate tachometer will join the family of inertial reference instruments in the field of angular rate measurement and will be available in form and performance characteristics to suit many application requirements. The instrument will encompass the range and response of many of the standard rate gyroscopes.

(*Concluded on page 106*)

Fatigue Life of Thick-Skinned Tension Joints

EDWARD W. THRALL, JR.*

Douglas Aircraft Company, Inc.

SUMMARY

The fatigue strength of tension splices in the wings of low load factor airplanes has always been a major design problem. In wings with thick skin, where a large portion of the total bending material is in the skin, the necessity for a good fatigue life is even more important. Because of an early fatigue failure in a tension joint of an experimental airplane during laboratory tests, a program was instigated to determine ways of improving the life of the joint. Thirty panels representing twelve different splice designs were tested. The results are presented in the form of an S-n diagram, which should be useful for designing splices of this type. The tests show that when a splice is made in the skin, but not in the stringer, an early fatigue failure results. It was found also that a splice of the skin and stringer can be made as safe from a fatigue standpoint as the basic sheet-stringer combination with no splice.

INTRODUCTION

THE PRESENT-DAY PROGRESS in aircraft design is making demands on the structural designer to develop wing structures that are superior to any previous design. In general, the wing design must be efficient from a weight standpoint, must be easy to assemble, and must require a minimum amount of tooling. Since all new airplanes are expected to obtain high speeds in flight, the designer must be cognizant of the flutter speed and rate of roll which will be required when considering the detail design. Last, but not least, the wing, along with the complete airplane, must have a maximum service life with minimum maintenance of the structure—that is, no fatigue failures.

The problem of fatigue has been placed last in the above paragraph because, more likely than not, it is the last thing to be considered by the designer when developing his structural design. Those companies dealing with fighter and attack-type aircraft have no occasion to be concerned about fatigue life from gusts. The limit flight load factors for this class of aircraft are usually about twice the limit gust load factor. In the design of transports and bombers, however, the gust criteria usually equal the flight load factor criteria. For these airplanes, the designer makes the static strength of the structure good for the gust loads but often ignores the fatigue life of the various structural details in a futile effort to save weight. It is agreed that there is a tremendous amount of fatigue information available but no convenient method of applying the results. This is probably the reason that no greater attempt is made to design for fatigue strength.

Let us consider a specific example of a design for an aircraft which resulted in the use of a high aspect ratio wing that contained integral fuel tanks. In order to obtain the required rate of roll and to meet the flutter requirements, it was decided to use thick cover skins on the wing. In order to meet the speed requirements, the wings were sweptback. An additional design condition was imposed requiring that the integral fuel tank portion of the wing structure be built, sealed, and pressure-tested prior to installation on the remainder of the wing and fuselage.

When a designer is faced with the problem of selecting a specific type of detail design, such as a tension splice, to be used for the wing structure, the simplest thing to do is to refer to previous designs and then adapt them to meet the new conditions. This particular approach did not yield the desired results for the design in question, so the most optimistic "new design" was chosen. This paper will describe the design and development of tension joints that will satisfy the design requirements with particular emphasis on the fatigue strength of the splice.

Fig. 1 shows a portion of the "new design" tension splice, wherein a $^3/_8$-in. 75S-T6 skin is spliced to a $^5/_{16}$-in. thick 75S-T6 skin at the starting point of the structural sweepback of the wing. It should be noted here that the thick skins shown were required for torsional stiffness and consequently provided 78 per cent of the wing-bending material—the remaining 22 per cent being contributed by the spanwise stiffeners.

The actual splice for the above wing skins was accomplished by placing a $^3/_8$-in. 75S-T6 butt splice plate on the inside of the wing skins and attaching it to both the outboard and inboard skins by three staggered rows of bolts. The stiffeners did not joggle or clip on to the splice plate but were stopped short of the splice plate. In order to transfer the load from the stiffeners to the splice plate, fingers from the plate were extended spanwise approximately 4 in. along both sides of the stiffener. The front and rear spar caps were attached to the skin in a similar manner, except for the inboard rear spar cap that had a machined joggle to allow the cap to extend over the splice plate. A three-sided corner gusset was provided on the outboard side of the bulkhead to give a slight gusset effect between the outboard rear spar cap and the splice plate. The use of tension bolts for the stiffeners, through the bulkhead, was avoided

Presented at the Structures Session, Annual Summer Meeting, IAS, Los Angeles, July 15–17, 1953.

* Design Specialist, El Segundo Division.

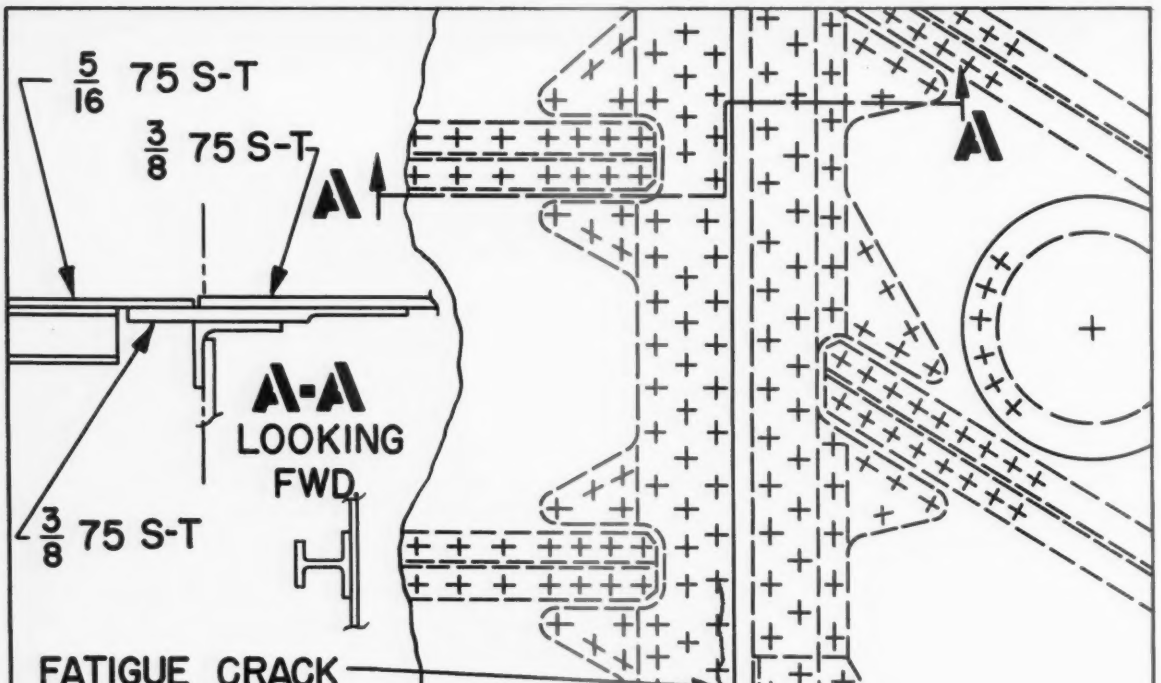


FIG. 1 ORIGINAL WING JOINT DESIGN SHOWING FAILURE.

because of fuel tightness problems. The static strength of this tension joint was verified by testing a representative sample of the joint to the calculated ultimate load.

Testing Procedure

When the design became a reality, it was necessary to comply with those contractual requirements that called for a static test and, because of the integral fuel tank, a repeated load test of the complete wing structure. This latter test required the application of a load on the wing structure which varies from 0 to 85 per cent of the maximum limit bending conditions with the fuel cell filled with gasoline under the maximum operational pressure. The loading cycle was to be repeated 1,000 times. The purpose of the tests was to determine the fuel tightness of the bolted and riveted joints throughout the tank bay. The air loads on the wing were simulated by numerous concentrated loading points that were joined together by appropriate linkages terminating at eight hydraulic jacks. The correct pressure was distributed to these jacks by an electrically driven hydraulic pump through a proportioning panel. The complete loading cycle took approximately 6 min. During the 445th cycle, a loud noise was heard, and the test was stopped. An investigation revealed that a crack had started in the splice plate just inboard of the closing bulkhead, extending forward from the rear spar for about 5 in. Fig. 2 shows the extent of the crack.

This early fatigue failure made it apparent that insufficient consideration had been given to the fatigue life of the tension joint. Because it was necessary to complete the thousand-cycle test, a redesign of the joint was in order. Because two airplanes, plus the static test article, had been completed, it was advisable to design a rework for these existing wings that could be installed with a minimum amount of disassembly. Before proceeding with any one specific design for the airplane rework, a fatigue test program was started to justify the change to be made. Several test specimens were made, each representing the portion of the wing in the region of the fatigue failure. The panels were straight tension members with the tension splice in the middle but with the structural sweepback omitted.

Attempts were made to test panels with sweepback using three loading points, but eccentricities, caused by the elongation of the test specimen, overloaded the panels and caused early failures. Studies indicated that the straight tension panels would be satisfactory. Because the panels were straight, the representative inboard skin was made the same thickness as the outboard skin. The actual skin on the airplane had different thickness inboard and outboard because of the load change at the point of structural sweepback. The details of the splice plate, stiffener end connections, and the simulated rear spar caps were made identical to those of the airplane. The first six types of tension joints tested had the following dimensions.

The center portion of the panels was 20 in. wide, with an angle on one side of the panel representing the rear spar cap and with one stiffener mounted near the center of the panel at the proper spacing away from the simulated rear spar cap. The gross area of the specimen was 9.65 sq.in. The load that was applied to each panel was determined from the strain-gage reading taken from the wing skin in the vicinity of the fatigue failure during the repeated load test. The maximum stress was 23,800 lbs. per sq.in., resulting in a load on the test panel of 230,000 lbs. The specimens were loaded by means of eight 20-sq.in. hydraulic jacks mounted in banks of four, as shown in Fig. 3. The load line was through the centroid of the cross-sectional area of the panel. An electrically operated hydraulic pump furnished pressure for the jacks through a pressure reducer that limited the maximum load. The pressure was turned on and off by a solenoid-operated valve at the rate of 3 cycles per min. with a counter connected to the solenoid to indicate the loading cycles for each panel. The structure that held the panels was sufficiently long to permit two panels to be tested simultaneously by connecting them in series.

Panel Tests

Test Panel No. 1.—The design of the first panel No. 1 was representative of the tension joint on the airplane which failed during the thousand-cycle repeated load test. The main object for performing the test on this specimen was to establish a basis for comparison with future designs. Fig. 4 shows the details of the splice and the failure. As stated previously, the maximum gross stress for the panel, considering the spar cap and stiffener to be fully effective was 23,800 lbs. per sq.in. The gross stress in the splice plate was 30,900 lbs. per sq.in., and the net stress at the point of failure was 39,900 lbs. per sq.in. The initial crack started on the end of the doubler that was in line with the rear spar cap. This was similar to the point of failure found on the airplane doubler. It should be noted that the doublers that failed in the test panel and in the airplane were loaded in a cross-grain direction. This direction of grain was necessary in the airplane because of the relative length and width dimensions. Two panels of this design were built and during the fatigue test one failed after 204 cycles; the second failed after 303 cycles. Both these panels withstood less than the 445 cycles experienced before failure on the static test airplane. The difference in the results is attributed to the lack of sweepback and the lack of chordwise curvature in the test panels. Both of these features, found in the airplane joint, would have added bending rigidity and

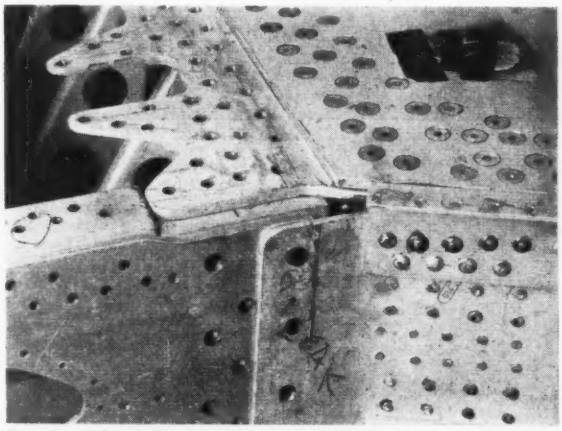


Fig. 2. Wing failure due to repeated loading at the 445th cycle.

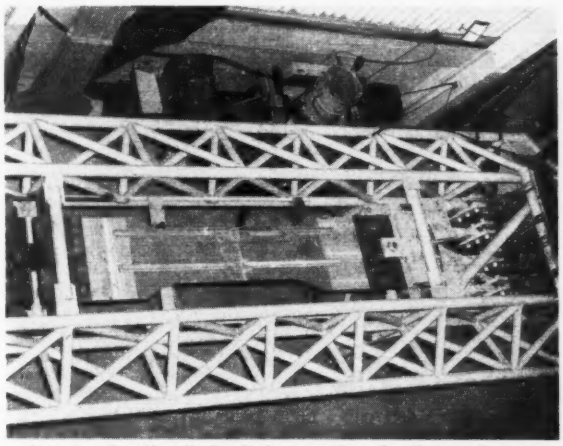


Fig. 3. Loading jig for fatigue testing of splice specimens.

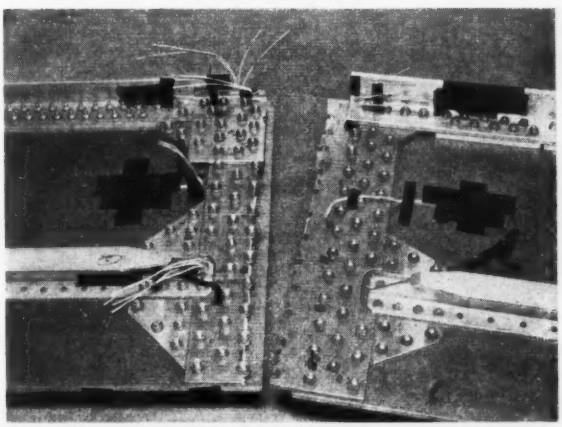


Fig. 4. Splice plate failure for test panel No. 1 after 204 cycles.

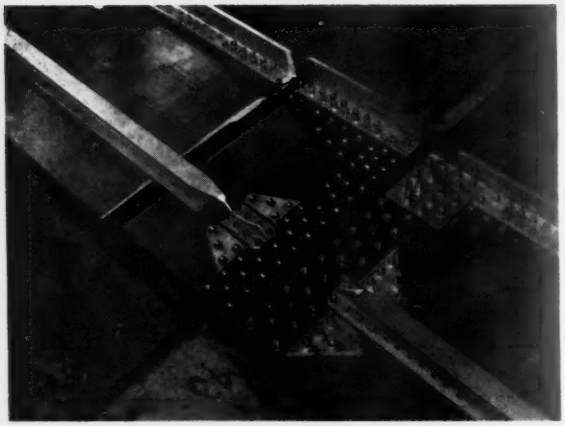


FIG. 5. Skin failure of panel No. 3 after 12,144 cycles.

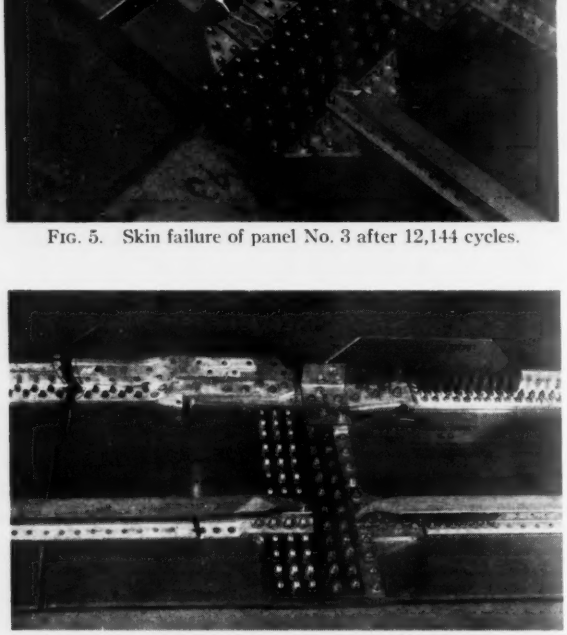


FIG. 6. Splice detail of panel No. 6 showing the failure.

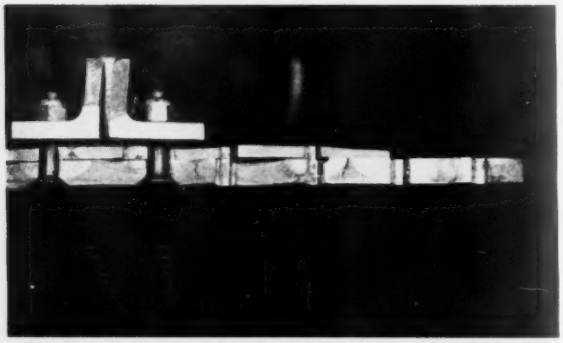


FIG. 7. Stress concentrations at bolt holes of panel No. 6.

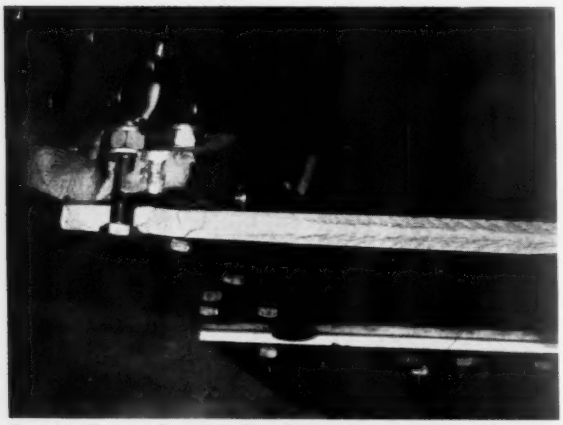


FIG. 8. Progression of fatigue failure in panel No. 6 (178,806 cycles).

strength to the test panel doubler and, consequently, would have added to the fatigue life.

Test Panel No. 2.—The structural details of the splice joint for this panel were made identical to those of panel No. 1 but with an additional 0.064-gage 4130 steel external splice plate. It had become apparent, after watching test panel No. 1 under the action of axial loads, that the bolts must be put in double shear to prevent bending of the internal splice plate. Since the wing was built with flush bolts, it was necessary to have a plate that could be dimpled into existing countersinks. The addition of an aluminum-alloy plate that could be dimpled into these countersunk holes seemed impractical because the gage of the material was too thin. By a trial and error method, it was found that an 0.064-cm. steel splice plate, heat-treated between the limits of 125,000 and 137,000 lbs. per sq.in., was the heaviest gage steel that could be dimpled satisfactorily. The addition of the steel plate reduced the gross stress in the splice plates to 20,500 lbs. per sq.in., with a net stress in the minimum section of 26,500 lbs. per sq.in. Two panels were built and fatigue-tested. The first panel withstood 712 cycles before that test was stopped, and the second panel withstood 1,225 cycles. The cycling of the first panel was stopped shortly after the first crack appeared, while the second panel was cycled until complete failure was experienced. This partially explains the difference found in the fatigue life of the two panels. The failure that occurred was typical of that found on the static test airplane and the No. 1 panels.

Test Panel No. 3.—A review of the failures of the four preceding test panels indicated that there was an uneven distribution of the axial load to the splice plate. It was reasoned that because the rear spar cap was on the edge of the sheet, the load in the splice plate varied considerably from an assumed average stress. Also, the fact that the inboard portion of the rear spar cap and skin formed a double shear connection to the single splice plate helps justify the foregoing reason. In order to cope with this extra load at the rear spar location, it seemed advisable to provide additional splice plate strength. The use of a local steel splice plate appeared to be an easy solution, so one was added to the panel. Fig. 5 shows the plan form of the internal steel splice. This steel plate was made of the same gage as the previous aluminum plate but extended spanwise along the rear spar cap approximately twice as far as the aluminum plate. The spanwise legs of the plate were tapered in thickness. An external 0.064-cm. steel plate, similar to that first used on panel No. 2, was used on this panel. Using the same load to cycle the panel, fatigue failures resulted after 4,483 cycles for one panel and after 7,234 cycles for the second panel. The second panel was loaded to an equivalent ultimate load prior to cycling, thereby giving a possible reason for the large differences in fatigue lives shown above. In order to assure adequate fatigue life at a different stress level, two more panels were built and tested. The gross stress for these panels was 17,400 lbs. per sq.in. The two panels tested withstood 11,750 and 12,144 cycles prior to failure. Fig. 5 shows the point of failure that

occurred on the inboard side of the splice, at the end of the internal steel plate. This panel design was the first to have a fatigue failure that was not in the splice plate.

Text Panel No. 4.—After testing panel 3 and obtaining such a large increase in the fatigue life compared to panel No. 1, it was felt that the increased life was due, in part, to the spanwise length of the steel plate rather than to the change in material. Therefore, panel No. 4 was designed to be exactly like panel No. 3 with the exception that the steel plate was replaced with a 75S-T6 plate loaded parallel to the grain. The first panel had a failure in this new doubler at the rear spar cap location after 2,109 cycles. The next panel had an initial failure after 1,041 cycles. Neither panel was carried to complete destruction. The load cycle was the same as for panel No. 1. The failures were at the same point on the doubler as found on the No. 1 panel, the No. 2 panel, and the static test airplane. It can be concluded that the steel doubler can carry the extra load and still have longer fatigue life than the skin.

Test Panel No. 5.—This panel was identical to panel No. 2, except that the external 0.064-gage 4130 steel plate was extended spanwise in the region of the rear spar. Panel 5A failed after 2,478 cycles, and panel 5B had a similar failure after 687 cycles. In neither case were these panels carried to complete destruction. The initial cracks again appeared at the rear spar cap side of the panels. Here again panel 5A had been loaded to ultimate static load prior to the cycle test which may account for the longer cycle life.

Test Panel No. 6.—Fig. 6 shows the details of panel No. 6 that was designed with the thought of giving still longer fatigue life than the foregoing panels. This design could be used only on the subsequent airplanes where no rework of existing structure would be involved. In order to overcome the load concentration at the rear spar cap, the caps were extended so that a lap joint between the caps was obtained. This provided an independent tie for the rear spar cap loads across the splice joint. The skins were spliced with a 0.375-in. internal plate, plus 0.188 external plates—both plates made from 75S-T6. The spanwise stiffeners were

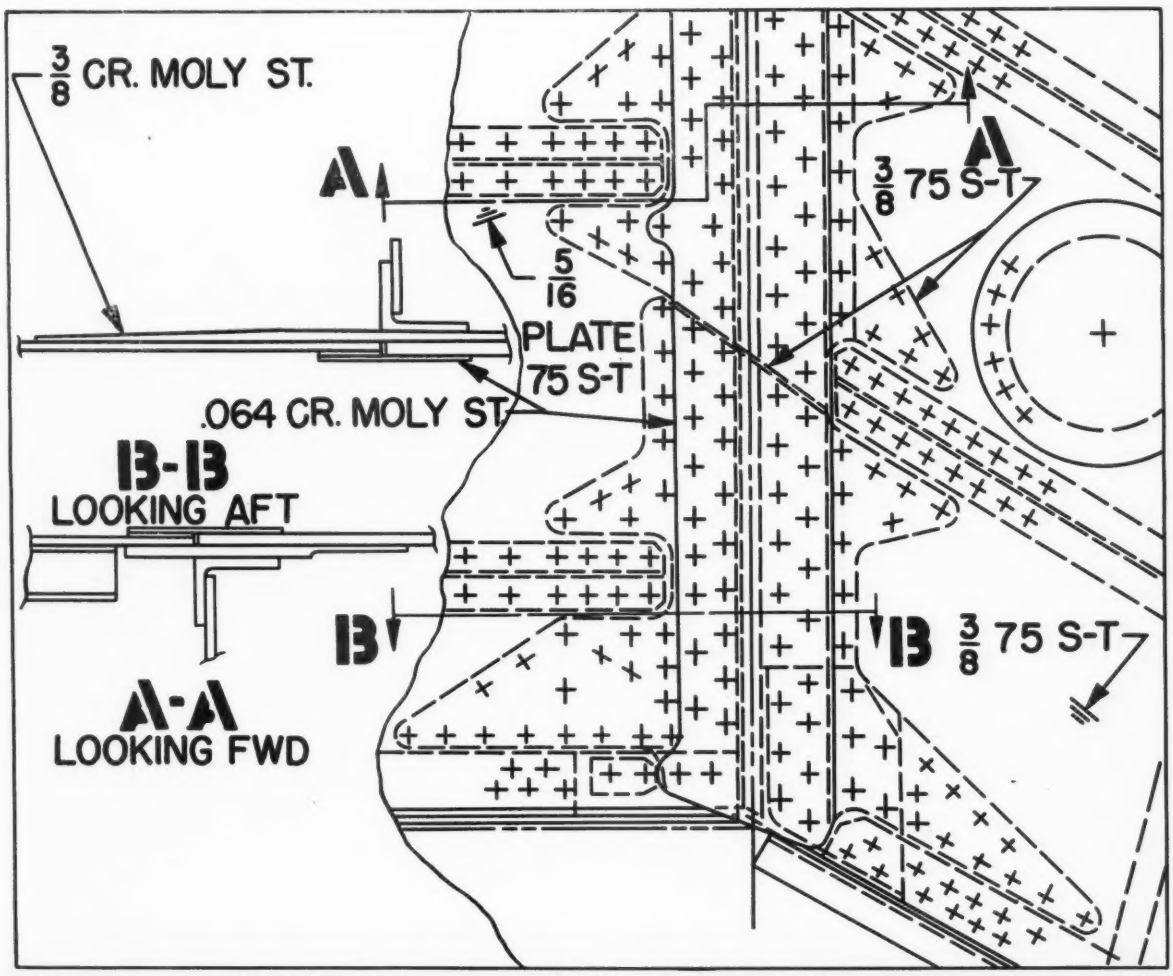


FIG. 9 REWORK OF WING JOINT AFTER FAILURE

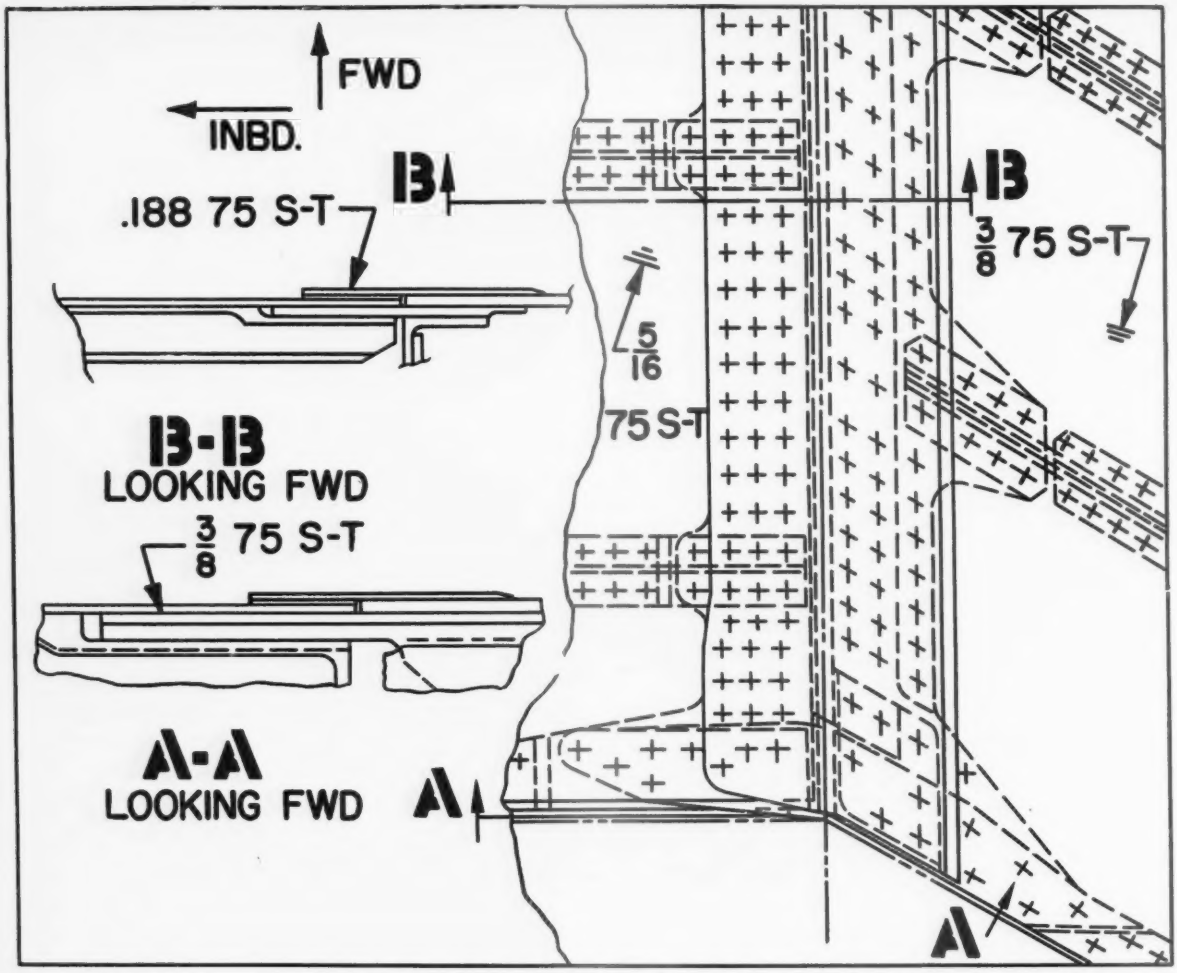


FIG. 10 FINAL CONFIGURATION OF WING JOINT

joggled onto the $^3/_8$-in. plate, the stiffeners on the outboard side of the bulkhead by means of separate fittings bolted to the stiffeners, and the center wing stiffeners by the use of a machined joggle. A 0.188-in. aluminum external plate was used in place of the external 0.064 steel plate that was used on panel No. 3. The first two panels were loaded to 8,799 and 6,502 cycles, at a load of 230,000 lbs. before failure. Two more panels were cycled to 17,028 and 17,471, before failure at a load of 173,000 lbs. This was the same reduced load that was used for panel No. 3. An additional two panels were then cycled through a stress range of 5,740 lbs. per sq.in. to 11,900 lbs. per sq.in. in order to obtain data for airplane fatigue life calculations. These two panels withstood 180,442 and 178,806 cycles before failing. Figs. 7 and 8 show close-up views of the fatigue failures that occurred on these panels. As would be expected, the failures all started at bolt holes.

Considerable time had elapsed since the failure occurred on the wing, and it was now necessary to choose which design should be used as a rework for the static test article and the two existing airplanes. Panels 2 through 5 represented the possible choices, with panel No. 3 showing the most promise. Panel No. 3 actually increased the life of the original tension joint between 10 and 15 times. Fig. 9 shows how the features of panel No. 3 were incorporated in the rework of the wing joint. Cycle tests of the wing were continued after the rework was completed until the required 1,000 cycles were obtained.

The splice design of panel No. 6 was chosen as the type to be used for those airplanes not yet built. This design was used rather than that of panel 3 because of the desire to get a greater length of service life for the airplane. Fig. 10 shows the incorporation of panel No. 6 into the design of the tension joint on the airplane. Note that the bolt patterns have been aligned rather than having a staggered pattern as found on the original design. Separate tests, using small panels, were run to determine the effects of staggered and inline bolt patterns. The nonstaggered bolt patterns gave the longest fatigue life.

Having started a test program, it seemed advantageous to continue the tests in order that more data might be obtained on fatigue life for different types of tension splices. These additional specimens were made

symmetrical. They did not possess the unsymmetrical features found in the first six test panels. It was felt that this would give a more general representation of the basic joint splice design problem.

Panel No. 7.—In order that the fatigue life for the basic structure might be determined, this panel was constructed with no splice at all. Fig. 11 shows the general arrangement of this panel. This panel was made from 0.375-gage 75S-T6 material and had a minimum width of 12 in. at the mid-span. This minimum width section was 6 in. long. Two panels were cycled at a gross stress level that varied from 0 to 21,900 lbs. per sq.in. The fatigue life at this stress level was 38,413 and 53,447 cycles. Two more panels were cycled over a stress range that varied from 0 to 42,000 lbs. per sq. in. with fatigue failures occurring after 7,360 and 7,205 cycles. Failures occurred in the center of these panels and seemed to be caused by load concentrations that occurred at the rivets that connected the stiffener to the skin. It was thought that there would be no load transfer in these rivets over the constant width mid-span section of the panel. However, strain gages indicated there was a slight difference in the stress between the plate and the stiffener which could have been produced by bending.

Panel No. 8.—The plan form of this panel was identical to that of panel No. 7. An additional row of rivets, representing a chordwise rivet attachment on the wing, was added across the mid-span of the panel. These were to be representative of a bulkhead attachment to the skin. Two panels were made and cycled through a stress level of from 0 to 21,900 lbs. per sq.in. The fatigue lives of these panels were 26,088 cycles and 35,702 cycles before failure occurred. Again the failure was started by the stress concentration of one of the rivets connecting the stiffener to the skin. The ultimate failure occurred through the line of chordwise rivets located at the mid-span of the panel. These chordwise rivets could be classified as unloaded rivets. In other words, they were merely rivets through the skin transferring no load to or from the skin.

Panel No. 9.—In order to determine the effects of splicing the skin, but not splicing the stiffener, panel No. 9 was built. The specimen was made from a sheet of 0.375-gage 75S-T6 material that was 24 in. wide at the center section, with two stiffeners equally spaced. The 0.375-in. thick skin was spliced by an external 0.188-in. splice plate and a 0.250-in. internal splice plate. These two splice plates were made from 75S-T6 and were loaded in a cross-grain direction. A machine joggle was made in the stringers so that they would pass on top of the 0.250-in. splice plate. The thickness of the leg in contact with the doubler was increased so that the total area of the stringer across the joint was the same as for the stringer away from the joint. Fig. 12 shows the details of the joggle. This panel was loaded to the same stress level that was used for panel No. 8, and failures occurred after 25,873 and 38,208 cycles. Figs. 12, 13, and 14 show the failures that occurred. In the second panel, the failures started

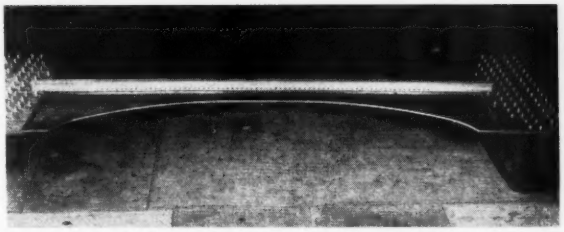


FIG. 11. Basis sheet—stringer combination used for panel No. 7.

FIG. 12. Fatigue failure of stringers on panel No. 9.

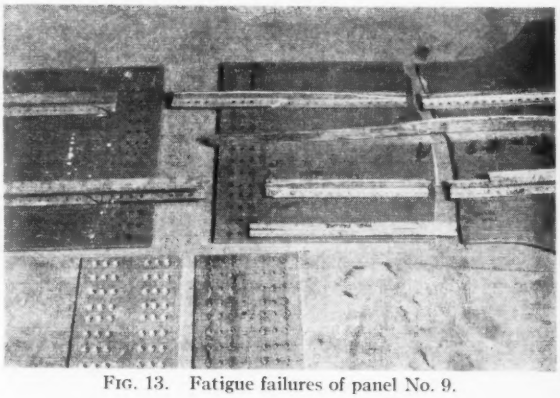


FIG. 13. Fatigue failures of panel No. 9.

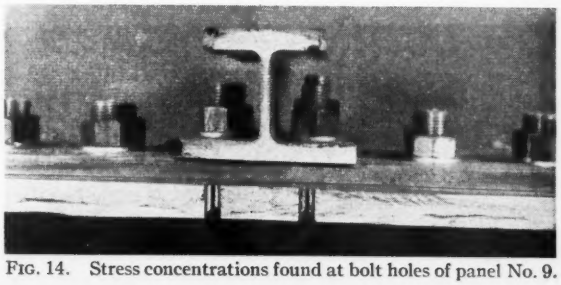


FIG. 14. Stress concentrations found at bolt holes of panel No. 9.

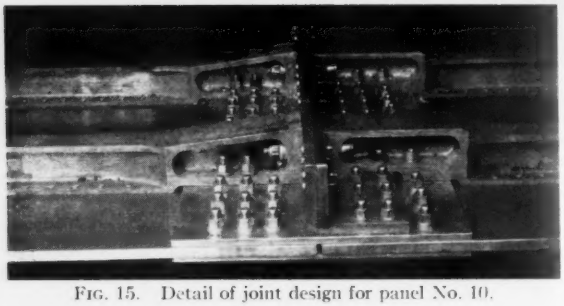


FIG. 15. Detail of joint design for panel No. 10.

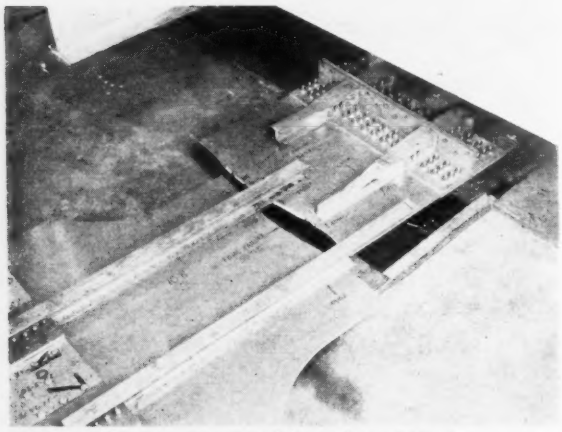


FIG. 16. Complete failure of panel No. 10.

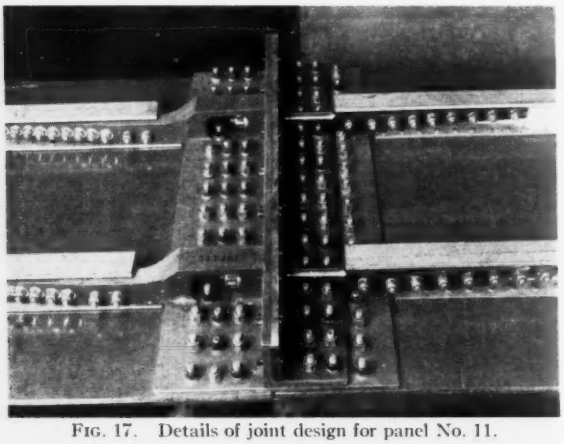


FIG. 17. Details of joint design for panel No. 11.

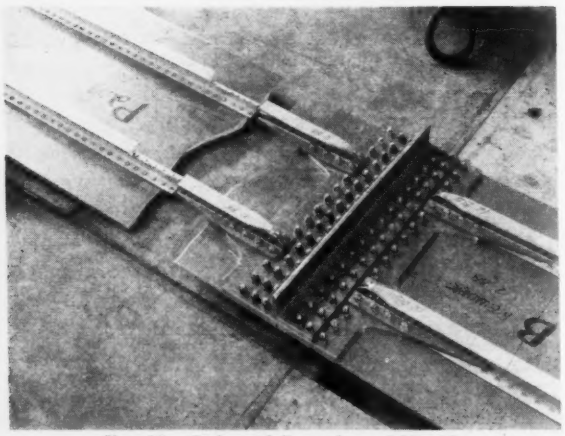


FIG. 18. Stringer failure of panel No. 12.

around 25,878 cycles with the cracks starting in the stringer at the point of the machine joggle. This is shown in Fig. 12. These cracks would progress until both stringers were completely broken in two. After the stringers had broken, the failure of the skin started some distance away from the splice area at a point where a load transfer from the skin to the stringer was large. This started a fatigue crack that resulted in the ultimate failure of the panel. Fig. 14 illustrates this type of failure showing the initial crack and the crack as it progresses away from the hole. In one of these panels, an additional 13,000 cycles was taken by the panel after the first crack appeared.

Panel No. 10.—The tension splice for this panel was designed with the thought of being the optimum that could be obtained in a tension joint splice for both the stringer and the skin. Fig. 15 shows the details of this joint. The two plates that splice the skin were the same as used in panel No. 9. The stringers contained integral bathtub-type fittings with two bolts joining each stringer across the joint. A representative bulkhead cap was also included in this specimen. This made the joggles and bolt clearances realistic. Cycling at a stress level from 0 to 21,900 lbs. per sq.in., the panels withstood 41,337 cycles and 50,918 cycles before failure. Fig. 16 shows a typical failure of the panel. In each case, the failure occurred from 12 in. to 20 in. away from the center of the splice and occurred after one or both of the stringers had failed. Here again, it was a case of the load transfer between the sheet and the stringer, causing a stress concentration around the river hole, that started a crack in the skin which progressed across the sheet. Prior to the failure of the stringer, the load transfer in these rivets is negligible. The important fact from the results of these tests is that the fatigue life is as good as that of panel No. 7, which had no splice at all.

Panel No. 11.—One step away from the optimum type of splice is the case where separate fittings for the stringer attachments are bolted to the stiffener rather than being integral with the stiffener. Fig. 17 shows the details of this panel. The fitting on the right side of the panel is steel, while the opposite fittings that house the nut are 75S-T6. The first panel had a failure in the aluminum fitting through the holes for the two bolts that connected the fittings to the splice plate. This failure occurred after 22,600 cycles. An analysis of this fitting, at the point of failure, showed an error had been made in the design. Insufficient material had been allowed at the section through the bolt holes to maintain the same stress level as was found in the stringer. The panel was reworked, replacing only those parts that had failed, and the panel retested. There was a failure of the main sheet after an additional 8,460 cycles had been applied to the panel. At the point of the second failure, the section had withstood over 31,000 cycles.

Panel No. 12.—This panel was a duplication of panel No. 6 with the exception of the rear spar details that were omitted. The two-stringer specimen was constructed to test the basic splice design. The external splice plate was maintained at a 0.188-in. thickness,

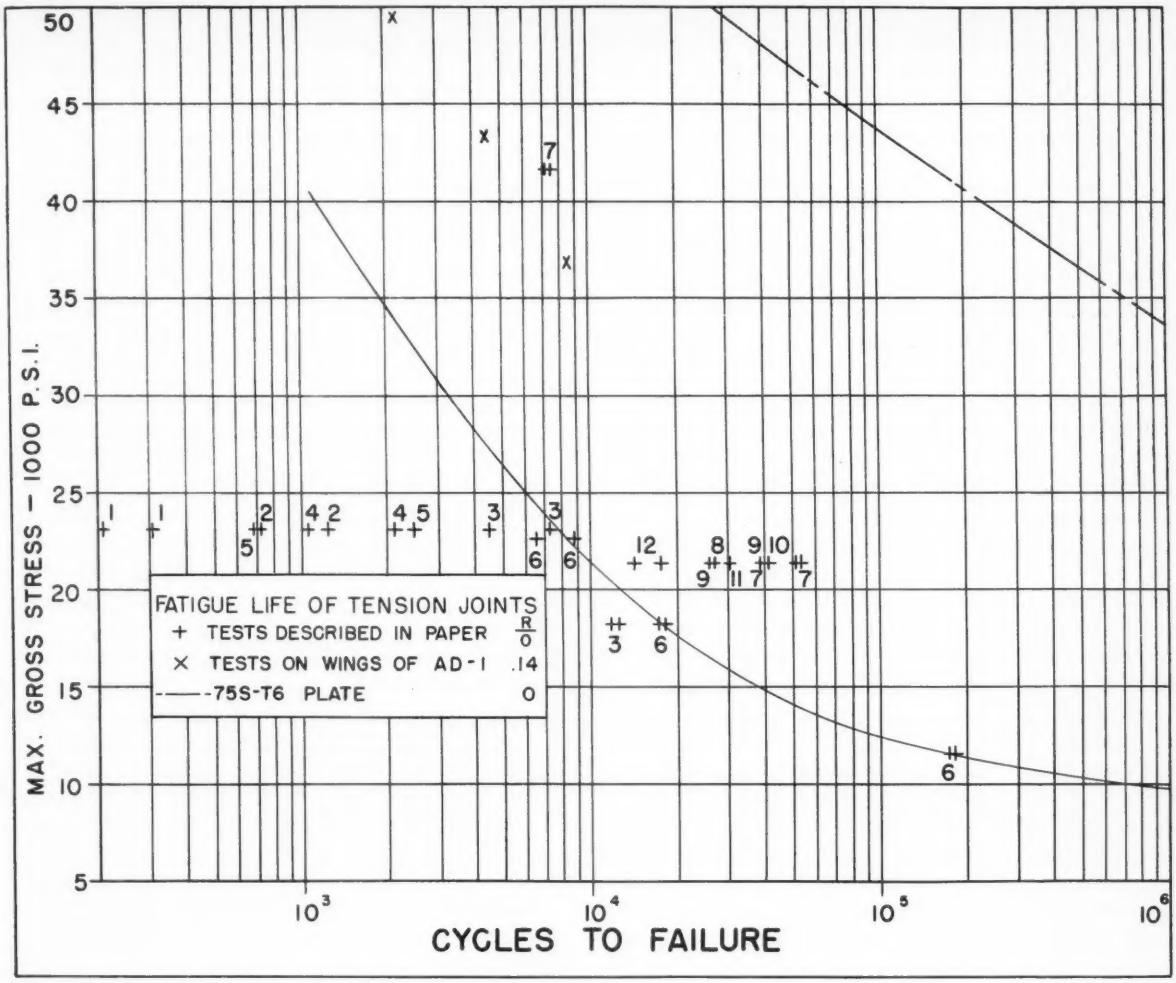


FIG. 19

and the internal plate was increased to 0.375 in. thickness. This was necessary because the stringer made no direct tie across the splice. The stringer load was transferred to the splice plate by means of two splice angles. The 0.375-in. internal plate of the first panel tested was machined down to 0.188 in. for the row of bolts farthest from the splice. During the tests, it was found that the crack would start at the end of the stiffener at the point where the machine step began. The first panel withstood 7,019 cycles before the above failure occurred. Since only the splice plates had failed, they were replaced and the panel retested. The internal plate was installed without the machined step previously used. This panel failed after an additional 7,038 cycles. The failure occurred in the stringer, through the line of bolts that joined the angle clips to the stringer. This gives an overall fatigue life for the panel of 14,057 cycles. (See Fig. 18.) The second panel was reworked to have the constant-thickness internal plate and withstood 17,118 cycles before failure. The stringers failed on this panel. A longer life could have been obtained for this type of splice if the web thickness of the stiffener had been increased. This panel withstood approximately twice the number of cycles obtained from panel No. 6. It appears that the asymmetry found on panel No. 6 reduces its fatigue life.

Discussion of Results

From the beginning, the plan has been to develop a satisfactory tension splice for the thick skin that is to be used in a wing design. This was accomplished through the various tests that were performed. Actually the tests can be divided into two categories; the first set of tests was for a specific example of a tension joint that was to be used to repair a fatigue failure, and the second series of tests was conducted to evaluate the relative fatigue life of all the tension splices investigated. In addition to the large panels described herein, some tests on smaller panels were conducted. These panels were only 6 in. wide but used the same 0.375-in. thick 75S-T6 plate. There were over 60 specimens tested in an effort to determine the effects of varying the bolt pattern. The basic pattern contained 12 bolts

in three rows in double shear. These 12 bolts were then rearranged in the different specimens to be in staggered rows, in tapered patterns, and in in-line patterns. Also, the distance between the rows was varied. The conclusions that can be drawn from these tests are as follows.

(1) The bolts in the different rows should be in line with one another.

(2) The rows of bolts should be as close as practicable.

(3) Each row should contain the same number of bolts, and the bolts should be of the same size.

The results of these bolt pattern tests were used in panel 6 and all subsequent panels by making the bolts in-line. The first five panels had staggered rows of bolts.

Having obtained the relative fatigue lives of the various types of tension joints, it was necessary to select the tension splice design that would be satisfactory when incorporated into a wing design. It is possible to make calculations that would give an indication of the life expectancy. The method that was used to make such life calculations is given in reference 1. In order to obtain an answer by this method it is necessary to have an S-n curve that is representative of the particular tension splice to be investigated. To accomplish this, the results from all the panels tested are shown in Fig. 19. The results from panel No. 6 have been joined with a line and the necessary information for the life calculations taken therefrom. There is still a considerable number of variables that must be arbitrarily assumed in order that the service life of the airplane be determined. First the anticipated flight history must be assumed—i.e., the percentage of time to be spent at each combination of speed and altitude. For the particular problem discussed here, an average combat problem life history, as given in the Detail Specification, was used. Next, it is necessary to consider what gusts are to be encountered. Two different assumptions were made which resulted in two different service-life times. The first calculation considered the application of plus and minus gusts occurring in pairs. That is, for every up-gust, there is an opposite down-gust, which results in a constant mean stress equal to 1g. This gives a complete stress reversal for each gust. An alternate calculation was made considering the application of plus and minus gusts taken separately, which means that there is a constant minimum stress and a constant maximum stress. This assumes that you strike only up-gusts half of the time and down-gusts the remainder of the time. The damaging effects of the up- and down-gusts are then accumulated to get the final service-life time. Using the S-n curve from panel 6, the first calculation yielded a service life of 1,193 hours, and the second calculation indicated a life of 10,530 hours. It is felt that these service-life indications cannot be too reliable in view of the large discrepancies caused by changing just one of the variables. The optimum way of solving this service-life problem would be to construct tension splice specimens from airplanes with a known service life. Then S-n curves could be obtained from these splice specimens, and the results would be representative of an actual service-life experience. Another thing that must be remembered is that, on the average, the maximum number of hours for military aircraft in service is equal to 1 year's service for a commercial aircraft. This means that the required service life will be in the neighborhood of 2,500 hours.

Conclusions

It has been the purpose of this paper to present the results of the fatigue tests on twelve different tension splices. The problem of fatigue in tension joints is indeed a critical item, particularly when thick-skin design is used and a fatigue failure can have catastrophic consequences. On the other hand, there is more and more demand to make the airplane structure less complicated and thereby cheaper and easier to build. With these two factors to be considered, the designer must choose some happy medium for his design.

Other companies have probably made fatigue tests on their own particular splice problems, but, in general, these data are not available to everyone. It is hoped that some day all of the fatigue data can be gathered together at one source. This will give an S-n curve or envelope within which the designer could safely locate his design and be assured that the fatigue life would be adequate, thus eliminating all service-life calculations. The other item for which more information must be obtained from all airplanes is the actual service life of the aircraft structures prior to fatigue failures. These data will substantiate the S-n envelope discussed above. In particular, the tests described here have shown that, when the skin is spliced without splicing the stringer or cap at the same station, an early fatigue failure of the caps will result. The tests have also shown that a tension splice can be made as satisfactory as the unspliced sheet-stringer combination. For military airplanes, which have a relatively short service life, the expense entailed by the optimum splice (such as panel 10) is not justified for an adequate service life.

Reference

[1] Jacobson, Joel M., *Problems of Aircraft Evaluation*, SAE Quarterly Transactions, October, 1949.

Evidences of an Inherent Error in Measurement of Total-Head Pressure at Supersonic Speeds*

JAMES S. MURPHY†

Douglas Aircraft Company, Inc.

SUMMARY

Calibration data obtained in an intermittent supersonic wind tunnel covering the Mach Number range $1.4 < M_t < 3.8$ are analyzed to show that the measurement of total-head pressure with a blunt-nosed, circular tube contains a small inherent error. In addition, the data indicate that a small "stagnation pressure loss" exists in the flow through the channel.

INTRODUCTION

THE ART of supersonic nozzle design and calibration has become sufficiently refined during the past few years to permit a comparison to be made between theory and experiment which shows where further work is desirable. This paper analyzes some results obtained by calibration of a particular supersonic channel with the desire to stimulate an interest in the presentation of data from other facilities so that further refinement of supersonic testing techniques may be realized. The data analyzed were obtained in an 8- by 13-in. supersonic tunnel at the University of Michigan. This intermittent tunnel has atmospheric pressure and temperature in the reservoir and has five sets of symmetrical nozzles producing discrete test Mach Numbers (M_t) in the range $1.4 < M_t < 3.8$. Each set of nozzles was calibrated by measuring static (p_s) and total-head (p_0') pressures and flow inclination at many points in the horizontal and vertical planes passing through the axis of the rectangular test section.

Analysis of the pressure data shows that a small "stagnation pressure loss" exists in the flow through the nozzle-test section and, in addition, that the measurement of a total-head pressure contains a small inherent error.

EXPERIMENTAL MEASUREMENTS

Calibration data[1, 2] were obtained by measuring static pressure with a cone-cylinder probe having an outside diameter of 0.065 in. with orifices located twelve cylinder diameters downstream of the shoulder between the cylinder and the 15° total angle conical nose. A 0.065-in. outside diameter blunt-nosed cylinder was used to measure total-head pressure. Initially, the measurements were assumed to be free of all except random errors, and Mach Number was determined at each point by the following three procedures:

(a) From ratio of static to reservoir pressure, assuming isentropic flow from the reservoir.

(b) From ratio of total-head to reservoir pressure, assuming isentropic flow upstream and downstream of the probe shock.

(c) From ratio of static to total-head pressures.

The Mach Numbers determined in this manner reflect the random pressure measurement errors, but, in addition, a consistent or systematic discrepancy between the three values at a given point is found. This discrepancy is such that:

Method (a) gives an intermediate value of Mach Number.

Method (b) gives a high value of Mach Number.

Method (c) gives a low value of Mach Number.

In the case of a particular point in the $M_t = 2.84$ nozzle to be discussed later in greater detail, these three Mach Numbers are, respectively, 2.85, 2.88, and 2.82 (see also Fig. 6). In general, method (c) is considered to yield the most reliable result since it contains no assumption concerning the type of flow from the reservoir to the point of measurement. Then, proceeding with the assumption that the Mach Number determined from (c) is true Mach Number, a local stagnation pressure, (p_{0L}) may be calculated from the measured static or total-head pressure. The distribution of p_{0L} along the test section axis of the $M_t = 2.84$ configuration is shown as Fig. 1. This distribution is typical of those found at M_t and indicates that p_{0L} varies slightly with axial coordinate in the test region. However, this variation may be considered as local deviation, produced by random pressure measurement errors, from some mean value. Additional data at other M_t indicate that p_{0L} is essentially independent of all space coordinates in the test region and is a function only of M_t. The average value of the ratio of local stagnation pressure to reservoir pressure, determined in the above manner, as a function of M_t is shown on Fig. 2 and is well represented by the equation

$$p_{0L}/p_0 = 0.9678 + 0.0633M_t - 0.035M_t^2 + 0.00415M_t^3 \quad (1)$$

for $1.40 < M_t < 3.8$.

Hence the assumption that the pressure measurements contain only random errors leads to the result that a stagnation pressure loss exists in the expansion through the nozzle which is a rather strong function of

* The work reported here was performed while the author was employed by the Engineering Research Institute, University of Michigan. He acknowledges the helpful comments of Prof. A. M. Kuethe and Dr. H. P. Liepman.

† Design Research Group, El Segundo Division.

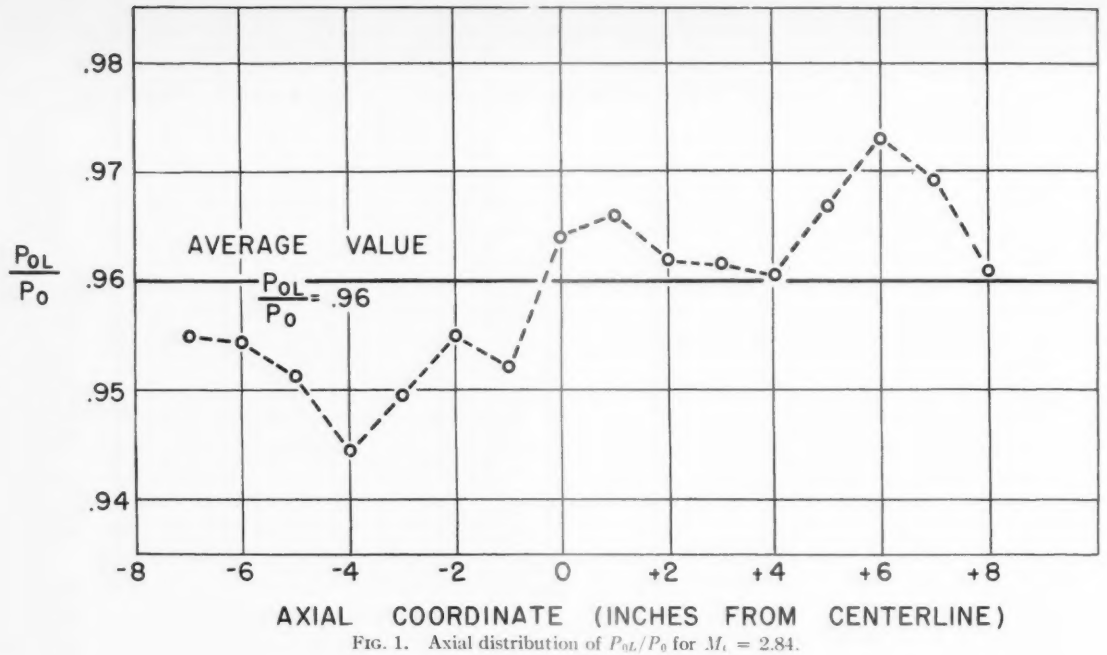


FIG. 1. Axial distribution of P_{0L}/P_0 for $M_t = 2.84$.

test section Mach Number. Examination of the possible origins of this loss indicates that only a portion of the loss given by Eq. (1) can be explained and that the remainder probably is the result of some form of inherent error contained in one of the pressure measurements.

ORIGINS OF STAGNATION PRESSURE LOSS

In an attempt to explain the origin of the stagnation pressure loss found experimentally, an analysis of the known possible causes of the loss will be presented.

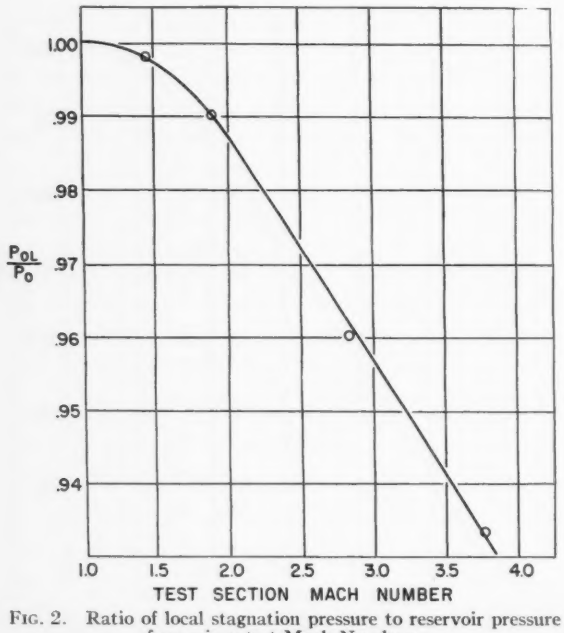


FIG. 2. Ratio of local stagnation pressure to reservoir pressure for various test Mach Numbers.

(A) Dissipation Due to Axial Velocity Gradient

Ordinarily, dissipation of energy due to viscous effects and heat transfer in a supersonic channel flow is considered to be restricted to the boundary layer along the channel surfaces. Losses that originate in the boundary layer influence the flow in the central portion of the channel only through a modification of the outer boundary condition, and this central core is potential flow. However, for small tunnels, large axial velocity gradients leading to a small dissipation of energy exist in the expansion from subsonic to supersonic velocity so that the central core is not potential flow.

A simple calculation shows that this dissipation causes only a negligible loss in stagnation pressure for the 8- by 13-in. tunnel. Assume that the channel flow is one-dimensional and that the dissipation is small so that the axial velocity, u, and its derivatives for the viscous flow are equal to corresponding quantities in the potential flow. Then the change in entropy, S, may be found by solution of the energy equation, written in the form

$$T\frac{dS}{dx} = \frac{1}{\rho}\Phi + \frac{1}{\rho}\frac{d}{dx}\left(k\frac{dT}{dx}\right) = \frac{4}{3}\nu\left(\frac{du}{dx}\right)^2 + \frac{1}{\rho}\frac{d}{dx}\left(k\frac{dT}{dx}\right) \quad (2)$$

where

T = local temperature
k = coefficient of thermal conductivity
ν = kinematic viscosity coefficient
Φ = dissipation function
ρ = density

Then

$$\Delta S = \int_0^x \frac{4}{3}\frac{\gamma}{T}\left(\frac{du}{dx}\right)^2 dx + \int_0^x \frac{1}{\rho T}\frac{d}{dx}\left(k\frac{dT}{dx}\right)dx \quad (3)$$

and since the entropy change is related to the stagnation pressure change by

$$\Delta S = R \log (p_0/p_{0L}) \quad (4)$$

it follows that, for $\Delta S \ll R$,

$$\frac{p_0}{p_{0L}} = 1 + \frac{4}{3R}\int_0^x \frac{\nu}{T}\left(\frac{du}{dx}\right)^2 dx + \int_0^x \frac{1}{\rho}\frac{d}{dx}\left(k\frac{dT}{dx}\right)dx \quad (5)$$

Evaluation of Eq. (5) for each of the configurations for which calibration data are available indicates that the loss in stagnation pressure associated with axial velocity gradients in the nozzle is negligible. For example, the calculated loss for the $M_t = 3.76$ configuration is

$$p_0/p_{0L} = 1.00000253 \quad (6a)$$

as compared to the experimental loss

$$p_0/p_{0L} = 1.07 \quad (6b)$$

(B) Dissipation Due to Weak Shock Waves

Study of schlieren photographs and static and total-head pressure data at the various M_t indicates that weak shock waves are present in the flow. A conservative estimate of the strength and number of these waves is given in Table 1.

From these data, the loss in stagnation pressure associated with the waves has been calculated, and the results are also tabulated. They show that the shock loss may be neglected in comparison to the measured loss. This point is brought out more strongly by the fact that 19, 3° deflection angle waves would be required to produce the measured stagnation pressure loss at $M_t = 3.76$, whereas only two 1° waves exist.

(C) Dissipation Due to Water Vapor Condensation

The calibration data were taken with a reservoir dew point of −25°F. or less. The criterion for maximum allowable dew point was determined for each M_t by recording the variation of test section static pressure as a function of reservoir dew point. The dew point at which the variation of measured pressure with dew point change was less than or equal to the random error in pressure measurement was noted and established as the maximum allowable dew point for operation. The allowable test dew points for all M_t were never less than −25°F., so that −25°F. was established as a general critical value.

TABLE 1

Nominal M_t	Strength of Wave	Number of Waves	p_{0L}/p_0
1.44	½°	4 waves, reflected once	1.000
1.90	¾°	4 waves, reflected once	0.999
2.84	1°	2 waves	0.999
3.76	1°	2 waves	1.000

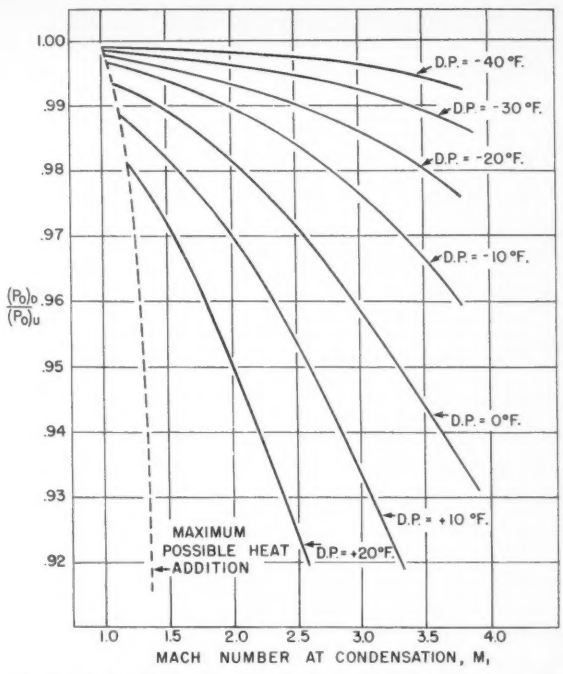


FIG. 3. Theoretical ratio of stagnation pressure across a normal condensation shock.

Even with a test dew point of −25°F., however, a small amount of water vapor may condense and cause a loss in stagnation pressure which should be taken into account. Hence, a series of calculations was made to find the theoretical influence of water vapor condensation on the properties of the test section flow. The analysis of Heybey[3] was followed in making these calculations. They contain the assumptions that the latent heat of vaporization of water is constant at 600 cal. per gr., that all vapor present in the stream condenses out, and that the water vapor content does not influence the value of the ratio of specific heats for air. Two independent parameters were used: (1) Mach Number at condensation, M_1, and (2) dew point of the reservoir air.

From the theory, the change in Mach Number and static pressure through a condensation shock was determined as a function of M_1 and dew point. By use of these results and the assumption of isentropic flow upstream and downstream of the condensation shock, the ratio of stagnation pressure upstream to that downstream of the shock was found. This ratio is shown on Fig. 3 as a function of M_1 and dew point, where the curves indicate that the loss in stagnation pressure can be appreciable depending upon the amount of vapor present and the location of the condensation shock.

If the assumption be made that condensation occurs at the test Mach Number, then the curves of Fig. 3 show that, for a dew point of −25°F., the loss in stagnation pressure due to condensation has the value

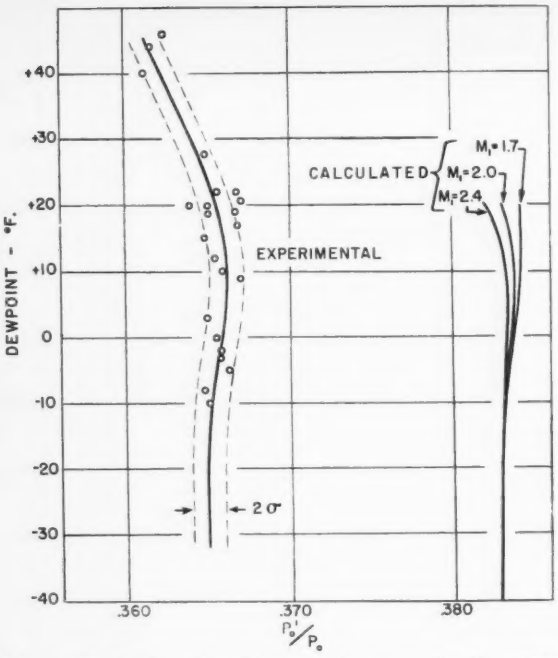


FIG. 4. Ratio of total-head to reservoir pressure for $M_t = 2.84$ nozzle.

given in Table 2 as a function of M_t. Also presented is the percentage of the observed loss which can be accounted for by condensation of water vapor. Actually condensation occurs at a Mach Number that is somewhat less than M_t, but as shown on Fig. 3 the above assumption is a conservative one.

The conclusion indicated by Table 2 is that water vapor condensation cannot account for all the observed loss in stagnation pressure for Mach Numbers above 1.50. Since dissipation due to axial velocity gradients and weak shock waves in the channel flow is negligible, it appears that the assumption that the measured pressures contain only random errors is not correct and that one or both of the measurements contains in addition some form of inherent error.

Experimental Measurements on Effect of Water Vapor Condensation

Since the conclusion that one of the measured pressures contains an inherent error is an important one, some further experimental measurements in addition to the calibration data were made to compare the theory of water vapor condensation with experiment. The measurements were taken at a point on the axis of the $M_t = 2.84$ testing region, where the calibration data gave a value of p_{0L}/p_0 equal to 0.963 (see Fig. 1).

TABLE 2

M_t	Theoretical Loss from Fig. 4	Measured Loss from Fig. 2	Per Cent of Loss Accounted for by Condensation
1.44	$0.003p_0$	$0.002p_0$	100
1.90	$0.0045p_0$	$0.01p_0$	45
2.84	$0.0092p_0$	$0.04p_0$	23
3.76	$0.177p_0$	$0.0667p_0$	26.5

Fig. 4 shows the measured value of the ratio of total-head pressure to reservoir pressure as a function of dew point, while Fig. 5 gives the measured ratio of static to reservoir pressure. These data were extrapolated to a dew point of −40°F. and were then used to determine the condensation-free Mach Number at the point of measurement from the ratio p_s/p_0'. From this Mach Number, theoretical variations of test section static and total-head pressures were computed as a function of dew point and M_1 and are also shown on Figs. 4 and 5. The variations of test section Mach Numbers computed by methods (a), (b), and (c) with dew point are shown on Fig. 6. According to the theory of water vapor condensation all three Mach Numbers should approach the same value for low dew points, but the curves of Fig. 6 indicate three distinct values.

Comparison of the theoretical pressure ratio curves with the measured values in Figs. 4 and 5 shows that both the static and total-head pressures follow the trend indicated by theory and that condensation occurs somewhere in the range $1.8 < M_1 < 2.4$ depending on the dew point. The experimental ratios, however, are lower in value than the theoretical ratios by an amount that is many times the experimental scatter. This discrepancy supports the conclusion reached in the preceding section that one of the measured pressures contains an inherent error.

Errors in Measured Pressures

(A) *Nature of Inherent Error*

The inherent error in one of the measured pressures could arise as a result of the flow about a probe or as a result of some malfunctioning of the measuring device. The latter is unlikely since several different devices were used to measure the pressures. Thus one is led to an inquiry concerning the nature of any inherent error due to flow about the probes with which the pressures were measured.

In order to bring the Mach Number data determined by methods (a), (b), and (c) into agreement, an inherent error in static pressure would have to be such that the measured pressure is higher than the true static pressure; on the other hand, an inherent error in total-head pressure would have to be such that the measured pressure is lower than the true pressure.

(B) *Inherent Error in Measured Static Pressure*

Theoretical and experimental results indicate that the pressure measured 12 diameters downstream of the shoulder on a small cone-cylinder aligned with a stream is essentially free-stream static pressure. Actually, because of the nature of the pressure distribution over this body, any inherent error would be such that the measured pressure is less than true static pressure, which is opposite in sign to that needed to bring the Mach Number data into agreement. Hence, one is led to the conclusion that the inherent error that must be

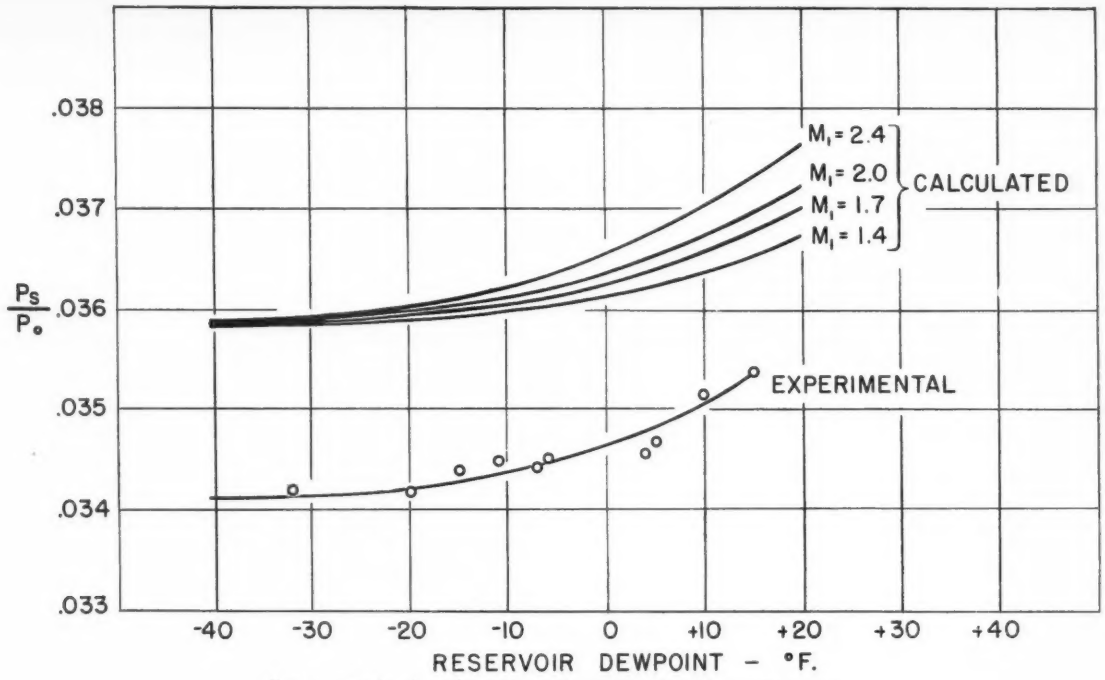


FIG. 5. Ratio of static to reservoir pressure for $M_1 = 2.84$ nozzle.

found is associated with measurement of total-head pressure.

(C) *Inherent Error in Measured Total-Head Pressure*

The total-head pressure measured with a blunt-nosed, circular tube may be less than true pressure due to the following:

(1) Viscous dissipation arising from large axial velocity gradients downstream of the probe shock wave.

(2) A complex flow field around or inside the probe tip such as backflow or rotational flow.

Staros[4] has investigated (1). His approximate values for the effects of viscous dissipation, however, account for only 10 per cent of the error found from the present measurements. Hence, an experimental investigation of the flow field about the total-head probe to determine the effect of (2) on the measurements appears in order.

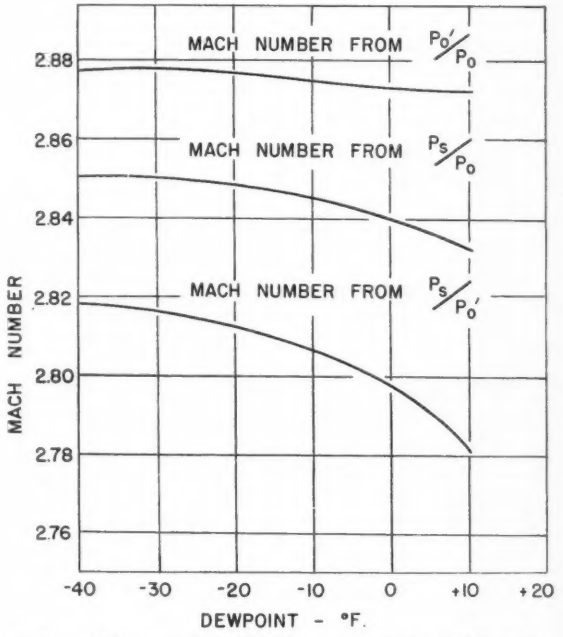


FIG. 6. Measured Mach Number as a function of dew point.

REFERENCES

[1] Culbertson, P. E., *Calibration Report on the University of Michigan Supersonic Wind Tunnel*, Univ. of Mich., UMM-36, November, 1949.

[2] Culbertson, P. E., *Calibration Report on the Flow in the U.M.E.R.I. Supersonic Wind Tunnel at Nominal Mach Numbers 2.84 and 1.44*, Univ. of Mich., WTM-213, June, 1952.

[3] Heybey, *Analytical Treatment of Normal Condensation Shock*, NACA TM-1174, July, 1947.

[4] Staros, B., *Investigation of Effect of Energy Dissipation Behind a Detached Shock Wave on Total-Head Measurements*, A.E. Thesis, Cal. Inst. Tech., 1950.

IAS Preprints

Preprints of Annual Summer Meeting Papers Currently Available

		Member Price	Nonmember Price
426	Wing-Body Interference at Subsonic and Supersonic Speeds: Survey and New Developments—H. R. Lawrence and A. H. Flax.	$0.35	$0.75
424	Design of the Hiller HJ-1, YH-32 Helicopter—H. Holm.	0.35	0.75
423	Afterburners—Are They Worth While?—F. C. Newton.	0.35	0.75
422	Fatigue Life of Thick-Skinned Tension Joints—Edward W. Thrall, Jr.	0.50	0.85
421	Spreading of Supersonic Jets in Supersonic Streams—John G. Wilder, Jr., and Kenneth Hindersinn.	0.65	1.00
420	Energy Approach to the General Aircraft Performance Problem—Edward S. Rutowski.	$0.50	$0.85
419	Optimum Design Considerations for Aircraft Wing Structures—Aaron L. Kolom.	0.50	0.85
418	Techniques for Determining Thrust in Flight for Airplanes Equipped with Afterburners—L. Stewart Rolls and C. Dewey Havill.	0.35	0.75
417	Optimum Exit Nozzle Performance for Jet Engines—Richard G. Laucher and John S. Winter.	0.35	0.75
416	Applications of Hypersonic Thin-Body Theory—Milton D. Van Dyke.	0.50	0.85

Other Preprints of Papers Currently Available

415	What Magnetic Amplifiers Can Do To Increase Aircraft Reliability—G. F. Schroeder.	$0.35	$0.75
413	Adaptability of Electronics to Aircraft Engine Control—Joel D. Peterson and Robert W. Curran.	0.35	0.75
412	A Simple Thrust Indicator for Propeller-Driven Airplanes—A. W. Vogeley and M. N. Gough.	0.35	0.75
411	Experimental Investigation of the Characteristics of the Supersonic Laminar and Turbulent Boundary Layer at M = 3.1—W. S. Bradfield, D. G. DeCoursin, and C. B. Blumer.	0.65	1.00
410	Effects of Articulated Rotor Dynamics of Helicopter Automatic Control System Requirements—Charles W. Ellis.	0.50	0.85
409	An Exact Solution for the Buckling Load of Flat Sandwich Panels with Loaded Edges Clamped—S. V. Nardo.	0.50	0.85
408	**(See Sherman M. Fairchild Fund Paper** No. FF-8.)		
407	The Structural Tail-Load Problem—Theory, Tests, and Criteria—Richard Koegler.	0.35	0.75
406	The Creep Deflections of Beams and Columns—Yoh-Han Pao and Joseph Marin.	0.35	0.75
404	Studies of Some Effects of Airplane Configuration on the Response to Longitudinal Control in Landing Approaches—R. W. Stone, Jr., and W. Bihrle, Jr.	0.50	0.85
401	Military Air Cargo Carrier Trends—Walter Tydon.	$0.35	$0.75
400	Forward-Flight Lateral Stability and Flying Qualities Studies of the Tandem Helicopter—K. B. Amer.	0.35	0.75
398	Subsonic Compressibility Corrections for Propellers and Helicopter Rotors—E. V. Laitone and L. Talbot.	0.50	0.85
397	Supersonic Flow About Slender Bodies of Elliptic Cross-Section—A. Kahane and A. Solarski.	0.65	1.00
396	Some Aerodynamic Effects of Streamwise Gaps in Low-Aspect-Ratio Lifting Surfaces at Supersonic Speeds—Z. O. Bleviss and R. A. Struble.	0.65	1.00
394	Stress Analysis of Sheet Stringer Panels with Cutouts—H. G. McComb, Jr.	0.65	1.00
393	Notes on the Analysis and Design of Multi-Post Stiffened Wings—D. M. Badger.	0.65	1.00
388	The Effect of Propeller Control Parameters on Gas-Turbine Power Ratings and Flight Efficiency—R. C. Treseder, M. Brooks, and J. R. Kessler.	0.35	0.75
386	The Shock Ignition Engine—Frank F. Rand, Jr.	0.35	0.75
385	Effect of Creep on Column Deflections—T. P. Higgins, Jr.	0.50	0.85

Preprints should be ordered by number from:

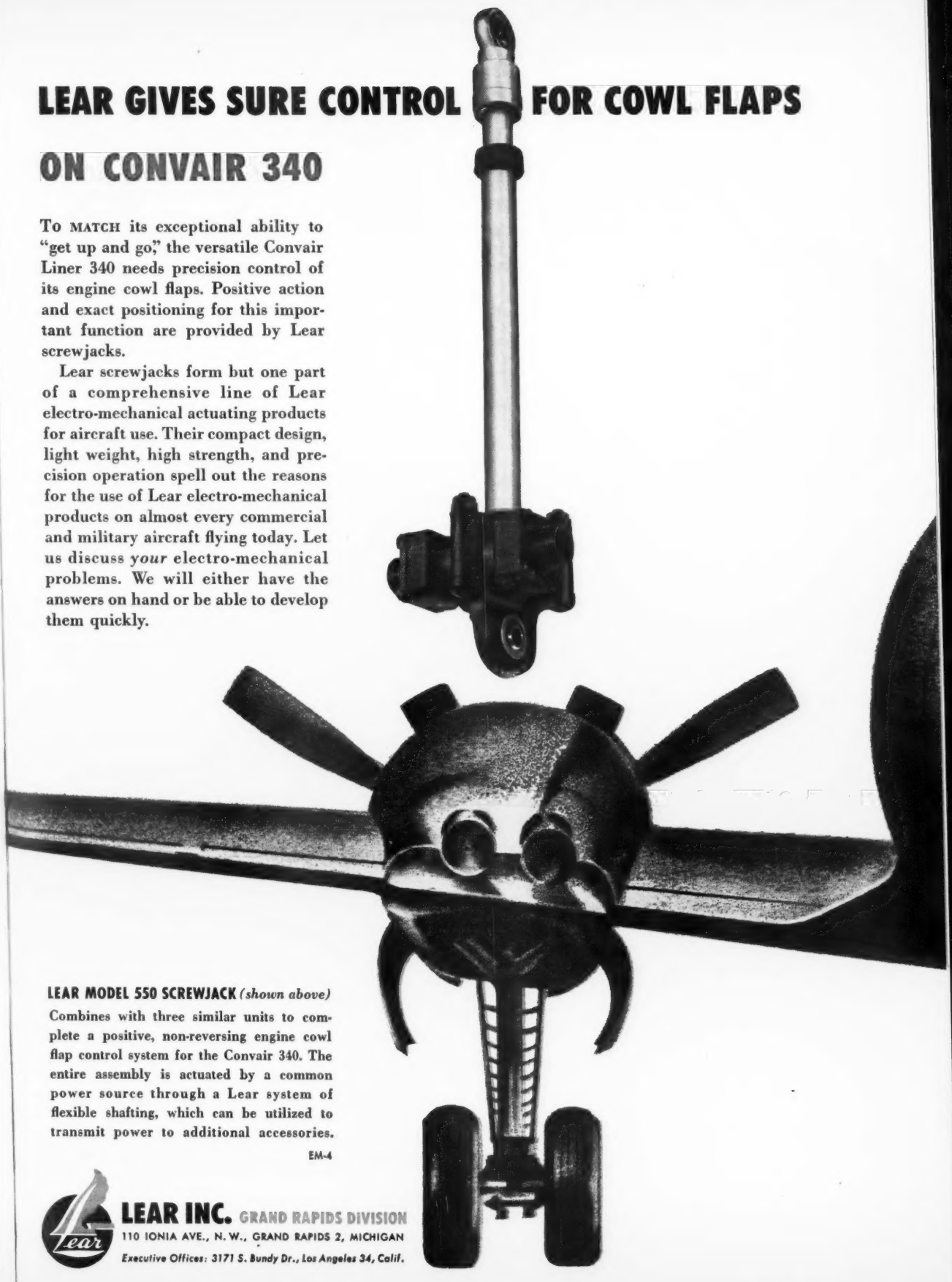
Preprint Department, Institute of the Aeronautical Sciences

2 East 64th Street, New York 21, N.Y.

LEAR GIVES SURE CONTROL FOR COWL FLAPS ON CONVAIR 340

To MATCH its exceptional ability to "get up and go," the versatile Convair Liner 340 needs precision control of its engine cowl flaps. Positive action and exact positioning for this important function are provided by Lear screwjacks.

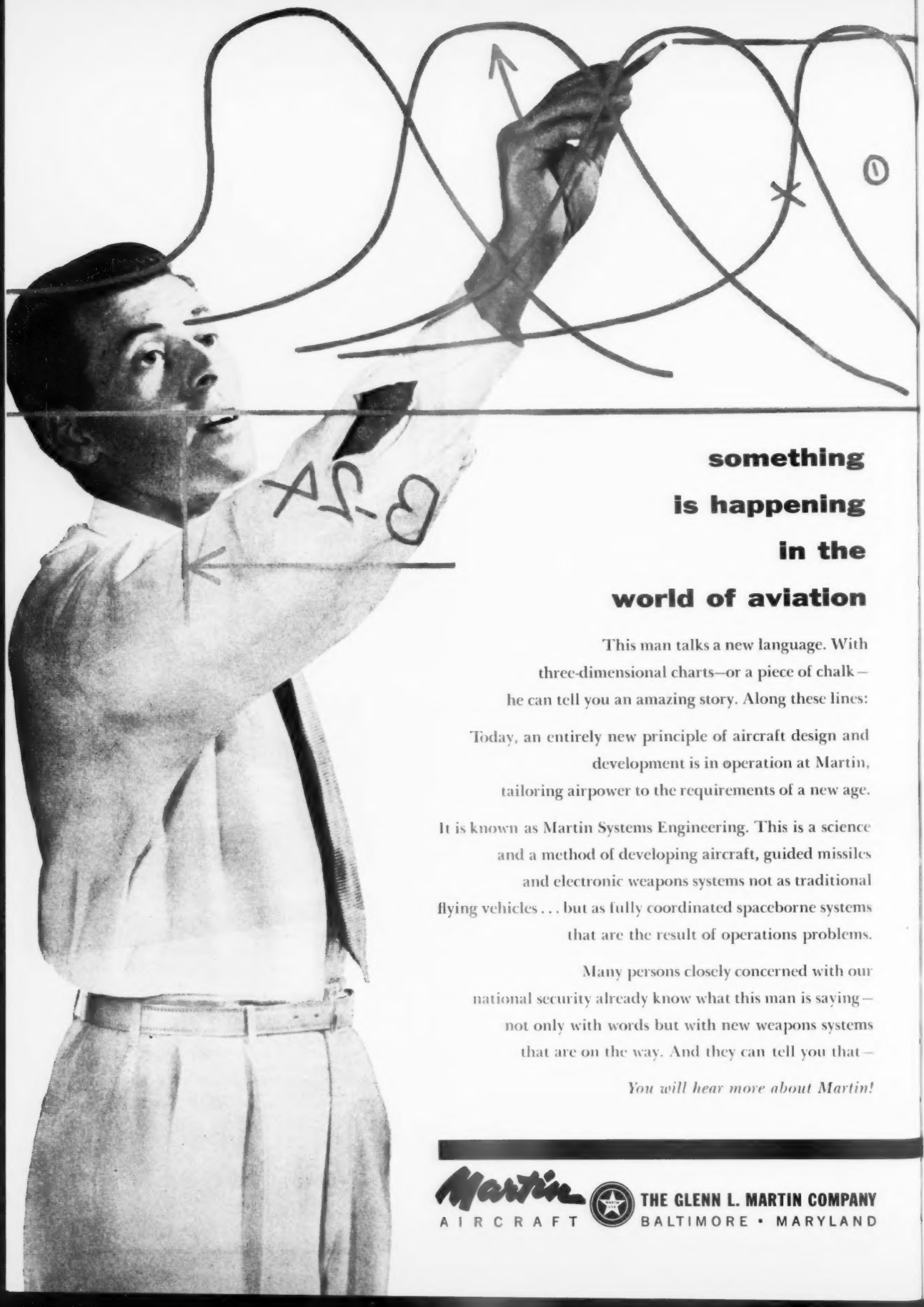
Lear screwjacks form but one part of a comprehensive line of Lear electro-mechanical actuating products for aircraft use. Their compact design, light weight, high strength, and precision operation spell out the reasons for the use of Lear electro-mechanical products on almost every commercial and military aircraft flying today. Let us discuss *your* electro-mechanical problems. We will either have the answers on hand or be able to develop them quickly.



LEAR MODEL 550 SCREWJACK *(shown above)*
Combines with three similar units to complete a positive, non-reversing engine cowl flap control system for the Convair 340. The entire assembly is actuated by a common power source through a Lear system of flexible shafting, which can be utilized to transmit power to additional accessories.

EM-4

LEAR INC. GRAND RAPIDS DIVISION
110 IONIA AVE., N. W., GRAND RAPIDS 2, MICHIGAN
Executive Offices: 3171 S. Bundy Dr., Los Angeles 34, Calif.



something is happening in the world of aviation

This man talks a new language. With three-dimensional charts—or a piece of chalk—he can tell you an amazing story. Along these lines:

Today, an entirely new principle of aircraft design and development is in operation at Martin, tailoring airpower to the requirements of a new age.

It is known as Martin Systems Engineering. This is a science and a method of developing aircraft, guided missiles and electronic weapons systems not as traditional flying vehicles . . . but as fully coordinated spaceborne systems that are the result of operations problems.

Many persons closely concerned with our national security already know what this man is saying—not only with words but with new weapons systems that are on the way. And they can tell you that—

You will hear more about Martin!

Martin AIRCRAFT

THE GLENN L. MARTIN COMPANY
BALTIMORE • MARYLAND

IAS Previews

Summaries of Current Papers Accepted for IAS Publications

Some Basic Concepts for Analyzing Dynamic Flight-Test Data

By

H. Klein and R. Sedney

Douglas Aircraft Company, Inc.

The problem considered here is that of finding, through the use of observed data, the coefficients of the differential equations that describe a dynamic system. This problem occurs in the determination of the aerodynamic stability derivatives of an airplane or missile from flight-test data. There is a maximum number of coefficients which may be determined. A method is given for finding this number, and conditions are given under which the maximum number is obtained. These results are summarized in a working rule and are applied to two examples. It is shown that the free oscillation type of flight testing can never yield all the coefficients. Suitable forcing functions are described which do permit all coefficients to be evaluated.

The Compressible Laminar Boundary Layer with Arbitrary Pressure and Surface Temperature Gradients

By

Deane N. Morris and John W. Smith

Bell Aircraft Corporation

The Kármán-Pohlhausen method is extended systematically to cover the hitherto unsolved problem of two-dimensional compressible laminar flow with arbitrary surface temperature and pressure gradients and arbitrary but constant Prandtl Number. The main features of this development are clearly distinguished from special numerical assumptions (e.g., particular boundary-layer profile representations), which are evaluated *a posteriori* and are subject to modification and refinement. Application of the present method to the calculation of heat transfer and skin friction in a given case involves the numerical integration of two simultaneous ordinary differential equations, which is readily accomplished by hand or with an automatic digital calculator. The theory is well adapted to an investigation of the combined effect of pressure and surface temperature gradients in the compressible boundary layer, for which no other practical method is available.

Solutions by the present method are compared with more exact solutions in the special cases for which the latter are available, and the agreement is good in all cases. The special cases used for comparison include skin friction for incompressible retarded flow, skin friction and heat transfer for incompressible flow over a special cylindrical shape, and skin friction and heat transfer for compressible flow over a flat plate, with and without a surface temperature gradient.

A sample problem is presented for a circular-arc airfoil at zero angle of attack in supersonic flow, with a specified surface temperature distribution. The local skin-friction and heat-transfer coefficients are determined as a function of distance along the surface and compared with the results obtained by application of the common flat-plate relations.

Single Degree of Freedom Flutter of Compressor Blades in Separated Flow

By

Jan R. Schnittger

Massachusetts Institute of Technology

Semiempirical results by Halfman, et al., are employed to demonstrate the existence of steady-state oscillations (limit-cycles) of pitching airfoils in separated flow (stall flutter). The flow around an oscillating two-dimensional airfoil was studied with a Mach-Zehnder interferometer. This investigation shows the prime effects of frequency $k = (\omega b)/v$, initial angle of attack α_i, cascade effect, and Mach Number on the aerodynamic reactions in separated flow.

Limit Design of Columns

By

Paul C. Paris

Fritz Laboratory, Lehigh University

An approximate load-axial deformation relationship is derived for pin end columns well into the inelastic range. A series of tests for L/i from 34 to 159 are shown for correlation with this approximation.

The concept of "plastic-dynamic buckling" is introduced to emphasize the strain-rate energy dissipation in early plastic buckling of columns. This physical concept is applied to a generalized structure whose maximum load-carrying capacity is reached in the inelastic range.

Please do not order Preprints of these papers at this time.
See page 52 for Preprints that are immediately available.

Interactions Between Wholly Laminar or Wholly Turbulent Boundary Layers and Shock Waves Strong Enough to Cause Separation

By

G. E. Gadd

National Physical Laboratory, Teddington, England

A qualitative discussion is presented covering both wholly laminar and wholly turbulent cases (i.e., where transition occurs upstream of the region of interaction). Relations are obtained for the pressures at separation with laminar and turbulent boundary layers. Semiempirical relations permitting the rapid calculation of the overall characteristics of turbulent interactions are also obtained.

A General Method for Solving Problems of the Unsteady Lifting Surface Theory in the Subsonic Range

By

H. G. Kuessner

Institute for Fluid Dynamics and Applied Mathematics, University of Maryland

An oscillating lifting surface of any shape with any downwash distribution

may be given. The Kutta condition of finite velocity at the trailing edge can be satisfied in a general way only if one introduces appropriate orthogonal coordinates. The lifting surface has to be a member of the family of orthogonal surfaces. Corresponding wave functions have to be used, by which the wave equation can be separated. By means of these functions a characteristic function G may be constructed, the normal derivative of which at the lifting surface has the properties of a Dirac δ-function. The kernels of the integrals, which represent the exact velocity potential and the pressure, are composed of this function G and its derivatives. Examples are given for the elliptic and circular plate and for the infinite long ribbon, for which the wave functions are known. The solution of the two-dimensional case is given also.

Sherman M. Fairchild Publication Fund Papers

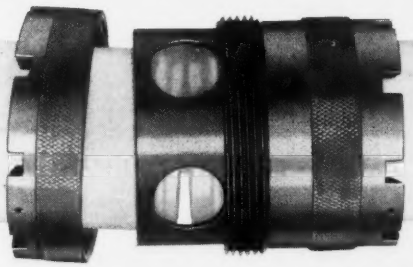
No.		Member Price	Non-member Price
FF-8	Compressive Buckling of Plates Due to Forced Crippling of Stiffeners, **Parts I and II**—P. P. Bijlaard and G. S. Johnston.	$1.30	$2.00
FF-7	Natural Flight and Related Aeronautics—James L. G. Fitz Patrick.	$2.65	$3.50
FF-6	Wetted Length and Center of Pressure of Vee-Step Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-5	Symposium on Standardization in Technical Information Services for Government Contractors.	$1.00	$1.00
FF-4	Finite Deflections of Curved Sandwich Plates and Sandwich Cylinders—F. K. Teichmann and Chi-Teh Wang.	$0.50	$0.85
FF-3	The Penetration of a Fluid Surface by a Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-2	A Study of the Flow, Pressures, and Loads Pertaining to Prismatic Vee-Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
AHS-1	Helicopter Flight Research at NACA, Langley—Jack P. Reeder.	$0.35	$0.75
286	Linearized Treatment of Supersonic Flow Through Axi-Symmetric Ducts with Prescribed Wall Contours—Charles E. Mack, Jr., and Ignace I. Kolodner.	$0.75	$1.25
244	Wetted Area and Center of Pressure of Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 30° Deadrise Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
166	An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
165	Theory and Practice of Sandwich Construction in Aircraft (A Symposium).	$1.85	$2.50
164	Applications of the Theory of Free Molecule Flow to Aeronautics—Holt Ashley.	$1.15	$1.50
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland.	$0.35	$0.50
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr.	$1.85	$2.50
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist.	$0.60	$0.80
101	Introduction to Shock Wave Theory—J. G. Coffin.	$2.65	$3.50
100	Blade Pitching Moments of a Two-Bladed Rotor—R. W. Allen.	$0.75	$1.00
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kanges, and G. L. Pigman.	$0.75	$1.00

Papers should be ordered by number from:

Publications Department, Institute of the Aeronautical Sciences, Inc.

2 East 64th Street, New York 21, N.Y.

WIG-O-FLEX COUPLING



flexible union for connecting rigid tubes.

are you interested in weight reduction?

WIG-O-FLEX COUPLING SAVES 17 POUNDS on B-66B

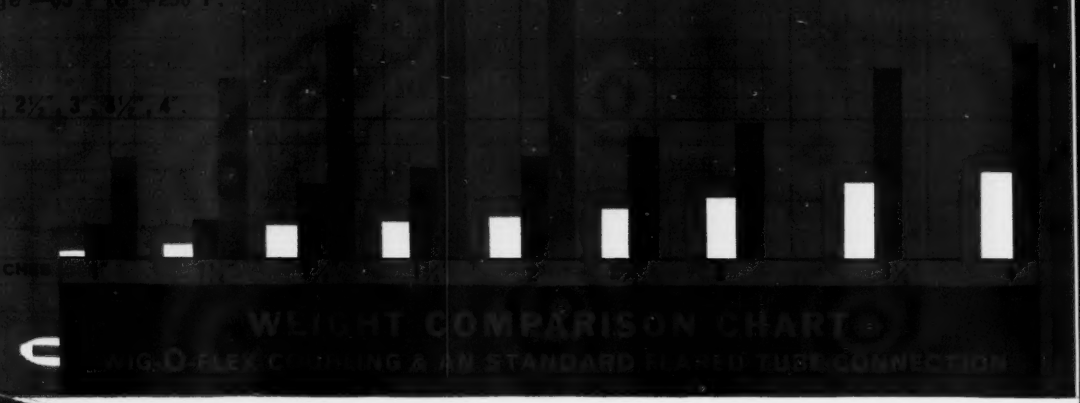
The New Douglas B-66B Bomber is 17 pounds lighter because WIG-O-FLEX Couplings replaced standard AN connections and cut hose. The WIG-O-FLEX Coupling weighs 1/6 as much as the standard AN connection it can replace. (See weight chart for exact comparisons.)

PROVED SUPERIOR FOR FUEL, OIL, AIR.

- Withstands more than 1800 psi burst pressure.
- Accomodates 4° tube flexure.
- Installs locally. 80% lighter.
- Temperature range —65° F to +250° F.

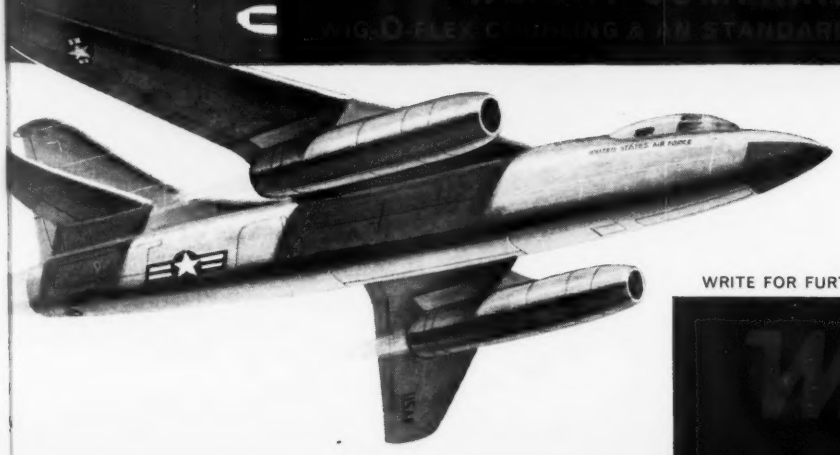
SIZES

1/4", 1/2", 1", 1 1/4", 1 1/2", 2", 2 1/2", 3", 3 1/2", 4".



WEIGHT COMPARISON CHART

WIG-O-FLEX COUPLING & AN STANDARD FLEX HOSE TUBE CONNECTION



WRITE FOR FURTHER INFORMATION.

Wiggins

E. B. WIGGINS OIL TOOL COMPANY, INC.

3424 East Olympic Boulevard, Los Angeles 23, California

Corporate Member News

(*Continued from page 21*)

prop-powered light plane, the Cessna XL-19B. This aircraft is powered with Boeing Airplane Company's 502-8 (XT50-BO-1) turboprop engine and was first flown in November, 1952.

• **Consolidated Vultee Aircraft Corporation. . .** A special promotion piece has been prepared and distributed by Convair in connection with their "hat" ad appearing on the back cover of this issue. It is a 16- by 19-in. folder with the words "Something we've kept under our hat. . . until now" inscribed on the outside and a wee Mallory hat (3.25 by 2.5 by 1.5 in.) in a red plastic hatbox inside the folder.

• **Eastern Air Lines, Inc. . . .** At a recent Board of Directors meeting, what is termed the "top management team" was elected as E.A.L. officers. At this time, Capt. Eddie Rickenbacker became Chairman of the Board, meanwhile retaining his position as Chief Executive Officer and General Manager. Thomas F. Armstrong, a Director and formerly Secretary-Treasurer, was made President. Thomas E. Creighton, Assistant Secretary, succeeded Mr. Armstrong as Treasurer, and Floyd Farley, Assistant Treasurer, succeeded him as Secretary. The other officers are: Paul H. Brattain, First Vice-President; Vice-Presidents Sidney L. Shannon, in charge of Operations; Leslie P. Arnold, Properties and Leases; Joseph H. Brock, Personnel and Industrial Relations; Charles Froesch, FIAS, Chief Engineer; M. M. Frost, Traffic and Sales; William Van Dusen, Advertising, Public Relations, and News Bureau; and Robert Ramspeck, Federal and State Regulatory Matters; and Willard Blackwood, Controller.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation . . .** The C-119 Flying Boxcar production has been moved into new manufacturing facilities at the Hagerstown, Md., plant. These new facilities are a part of the division's recent $9,000,000 plant expansion that added 328,000 sq.ft. of space to the previously existing 1,077,383 sq.ft. Nearly $7,000,000 of the $9,000,000 was furnished by the USAF; the rest was provided by Fairchild Engine and Airplane Corporation.

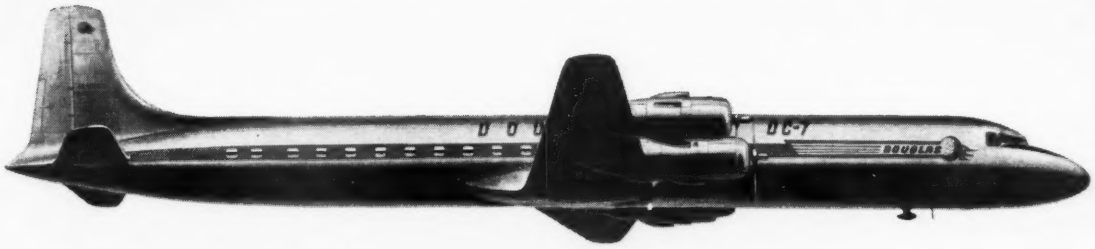
• **Fairchild Camera and Instrument Corporation . . .** Complete calibration records of all T-11 Cartographic Mapping Cameras produced by Fairchild have been presented in bound volumes to the Library of Congress. This is said to be the first time that complete optical calibration reports of aerial mapping cameras have been made a part of the public record in the Library of Congress.

• **Fairchild Engine Division, Fairchild Engine and Airplane Corporation . . .** An advanced design of the J-44 engine is to be installed in the Ryan XM-21, a remotely controlled aerial target to be used by the Army Ordnance to aid in training Army troops in the operation of the Skysweeper gun and various guided missiles. Special construction features have been developed in Fairchild's J-44 which are said to allow it to take the impact of a parachute landing without damage after a target run.

• **General Electric Company . . .** An Aircraft Nuclear Propulsion Department, with David Roy Shoults, AIFAS, as General Manager, has been established at the Evendale plant in Cincinnati and is engaged in the development of an atomic power plant for aircraft. This new department is made up of the personnel and facilities of the company's former Aircraft Nuclear Propulsion Project of the Aircraft Gas Turbine Division. It is now a component of G-E's Atomic Products Division, which is also headquartered at the Evendale plant and which is reponsible for all of the company's atomic energy activities. These atomic energy activities are conducted either directly for the Atomic Energy Commission or jointly for the AEC and agencies of the Department of Defense . . . A new mass flowmeter system for accurately measuring the fuel consumption rate of a jet aircraft engine has been announced by G-E's Meter and Instrument Department. This equipment determines fuel flow in pounds per hour and, according to G-E engineers, will aid pilots or flight engineers by simplifying the computation of total remaining flying time and by permitting a running evaluation of engine operating efficiency through comparison with experience data. The flowmeter is said to measure accurately the true mass rate of fuel consumption per engine. Detailed information on this system may be obtained by contacting G-E's Schenectady, N.Y., office and requesting the publication, *GEC-932*, on the mass flowmeter system. . . . It was recently announced that the Air Force has increased the allowable flying time to 1,200 hours between overhauls on all J47 jet engines except the J47-17 afterburner model. . . . The company's Specialty Motor Sub-Department is now producing a new air-cooled 3.5-hp. hydraulic pump motor that is rated at 7,500 r.p.m. This motor

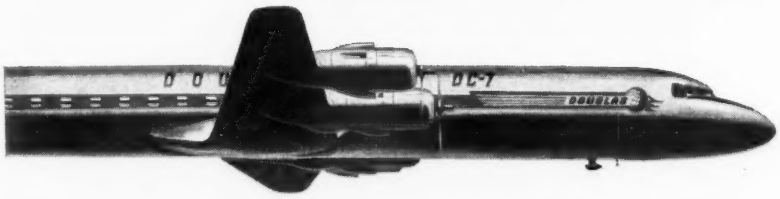
This is one of the 35,000-cu.ft. balloons used this past summer by Goodyear Aircraft Corporation of The Goodyear Tire and Rubber Company to train the first class of student blimp pilots since 1941. The students, who are training as Commercial Airship Pilots, are required to make a solo balloon flight of at least 1 hour. As soon as the balloon training and qualification phase is completed, the students are eligible for actual blimp flight training. The blimp training represents the final phase of the program.

As a result of tests conducted over a 3-year period by the Weapons System Branch of ARDC's Wright Air Development Center, the Fort Worth Division of Consolidated Vultee Aircraft Corporation, and Republic Aviation Corporation, a method has been developed whereby a B-36 can act as a carrier for reconnaissance fighter-type aircraft. The picture below shows a Convair RB-36F carrier plane and a "parasitic" F-84F Thunderstreak immediately prior to the F-84F's contacting the retrieving mechanism of the RB-36F. Both aircraft have modifications that enable them to take off and land as a single unit and which permit the Thunderstreak to be released and retrieved by the "mother" RB-36 while in flight. This development, which provides the Air Force with the capability for long-range high-speed reconnaissance with a high probability of survival for personnel and equipment, has proved versatile in that varied types of missions can be accomplished with limited changes or modifications of equipment and operational techniques.

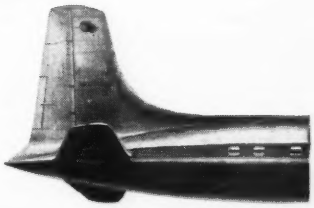


76 AiRESEARCH UNITS

ON EACH GREAT



NEW DOUGLAS DC-7



Another step forward has been taken in commercial aviation with the advent of the 400 mph DC-7. And as always when new sky frontiers are crossed, AiResearch products are doing a big job as part of the team!

Would you like to work with us?
Qualified engineers, scientists and skilled craftsmen are needed here.

AiResearch Manufacturing Company

A DIVISION OF THE GARRETT CORPORATION

LOS ANGELES 45, CALIFORNIA • PHOENIX, ARIZONA

DESIGNER AND MANUFACTURER OF AIRCRAFT EQUIPMENT IN THESE MAJOR CATEGORIES

Air Turbine Refrigeration | Heat Transfer Equipment | Electric Actuators | Gas Turbines | Cabin Superchargers | Pneumatic Power Units | Electronic Controls | Cabin Pressure Controls | Temperature Controls

A high-altitude reconnaissance aircraft, known to the Air Force as the RC-121C and to the Navy as the WV-2, is now in production at Lockheed Aircraft Corporation. A special version of the Lockheed Super Constellation, it carries more than 6 tons of radar and certain electronic devices. The upper and lower radomes and the elongated nose for this equipment can be seen in this photograph of an RC-121C. The plane is powered by four 3,250-hp. Wright Turbo-Compound engines and, despite the radomes, will approximate the 335-m.p.h. cruising speed of the air-line version. The plane is equipped to carry up to 31 crewmen and has a complete electronics maintenance shop. The RC-121C's will be used to give the USAF air-defense forces extra-early warning of approaching targets; the WV-2's will be used by the USN primarily to screen U.S. fleets. The WV-2's will be equipped to serve also as Navy fighter-plane directors, guiding carrier planes to enemy craft far beyond the radar reach of surface combat-information-center ships.

supplies hydraulic power for control of the aircraft's tail assembly and in the wings serves as a standby source of power where the jet engine is the primary source. It may be mounted either horizontally or vertically.

• **Jack & Heintz, Inc . . .** The new F137 inverter (motor-generator) for converting d.c. to a.c. power for instruments, controls, and other accessories recently completed the USAF altitude cycling tests for 50,000-ft. operation. (Full qualification depends upon flight-test results.) This 115-volt 400-cycle single-phase inverter is a substantially modified version of Jack & Heintz's standard rotary inverter and is capable of 1,500 va. output at 50,000 ft. and a 20°C. ambient temperature. . . . A new speed and voltage regulator assembly, designated as the FRS, is now being manufactured by Jack & Heintz. This FRS regulator was designed in conjunction with the company's new F137 high-altitude aircraft inverter and is being incorporated on all Jack & Heintz 1,500 and 2,500 va. inverters. This FRS regulator combines into one unit the functions formerly perfomed by two separate units, the speed governor and the voltage regulator. The measurements of the FRS approximate 5.5 by 6.25 by 3.25 in. Its weight is 4.5 lbs.

• **Lockheed Aircraft Corporation . . .** On August 13, the flight testing of two jet-boosted P2V Neptune aircraft was begun. The auxiliary jets, each producing 3,400 lbs. of thrust, supplement the ship's two turbocompound engines. One of the experimental aircraft is a P2V-6, which is being tested in California by Lockheed pilots. The other plane is a P2V-5, which is being put through its paces by the U.S. Navy's fleet air arm. . . . The twenty-five thousandth airplane built by Lockheed since 1932 came off the assembly lines at Burbank, Calif., on August 20. The airplane was an F-94C Starfire.

• **McDonnell Aircraft Corporation . . .** Under the terms of a USAF preproduction contract, the corporation is now tooling up for the production of a "new-type" photoreconnaissance jet fighter, the RF-101A. . . . L. E. Williams, McDonnell Vice-President and the corporation's Washington, D.C., representative, retired on August 14.

• **Minneapolis-Honeywell Regulator Company . . .** Arnold Michelson, who has been stationed in New York as the company's Manager of the Eastern Region, has been given additional duties and responsibilities as Resident Vice-President. He will continue to make his headquarters in New York.

• **North American Aviation, Inc. . . .** The first F-86H to come off the production line at the Columbus Division plant made its first flight on September 4. The F-86H is the fifth in the Sabre series and the second Sabre model to be built at Columbus. It is slightly larger than the previous Sabre models and is powered by a General Electric J-73 jet engine. It carries six 0.50-cal. machine guns. All controls in the "H" are hydraulically operated. . . . A miniature intercommunication system, measuring 3.75 by 5.75 by 7.375 in., has been developed for use in the company's Navy T-28B trainers now in production. This unit provides for communication between cockpits for receiving any of six separate communications and navigation signals, for handling a command signal, and for transmitting. It can be adapted to military aircraft other than the T-28B and to commercial planes. . . . A new building, scheduled to be ready for occupancy by the middle of last month, has been leased from Airport Building Development Corporation, of Los Angeles. This Los Angeles facility, which has 126,000 sq.ft. of floor space and 8½ acres of ground, is to be used by North American's F-100 fuselage assembly departments.

• **Northrop Aircraft, Inc. . . .** It has been revealed by the Air Force that the F-89D Scorpion, an all-weather interceptor, carries 104 2.75 folding fin air-to-air rockets in its wing-tip pods. These rockets, it is said, can be fired in a single, giant volley or in groups. Thus, the F-89D can make as many as three passes at a single target or move in for the kill on three separate enemy aircraft. . . . An exclusive license to manufacture and market a flexible stretch-form block used as a machine attachment with stretch presses has been awarded by Northrop to Hufford Machine Works, Inc. This flexible stretch-form block was originally designed and developed by Northrop tooling engineers to provide a flexible and economical method of producing small preproduction quantities of curved sections. Although it was originally designed for use with an A10 Hufford stretch press in the Northrop plant, it is adaptable for use with other existing types of stretch-press equipment.

• **Republic Aviation Corporation . . .** Major General Alden R. Crawford, USAF (Ret.), was recently appointed General Manager of Republic Aviation International, S.A. General Crawford is headquartered at the subsidiary's office in Lugano, Switzerland.

• **A. V. Roe Canada Limited . . .** Air Marshal W. A. Curtis, RCAF, recently Chief of Staff for the Royal Canadian Air Force, was appointed Vice-Chairman of Avro's Board of Directors.

• **Rohr Aircraft Corporation . . .** The election of four of the firm's personnel to vice-presidential positions was recently announced. The four persons concerned are: Frank E. McCreery, MIAS, from Executive Chief Engineer to Vice-President—Engineering; Charles E. Barnes, from Manager of the Riverside (Calif.) plant to Vice-President and Riverside plant Manager; A. F. Kitchin, from Production Manager to Vice-President—Administration; and B. F. Raynes, from Chief Tool Engineer to Vice-President—Manufacturing.

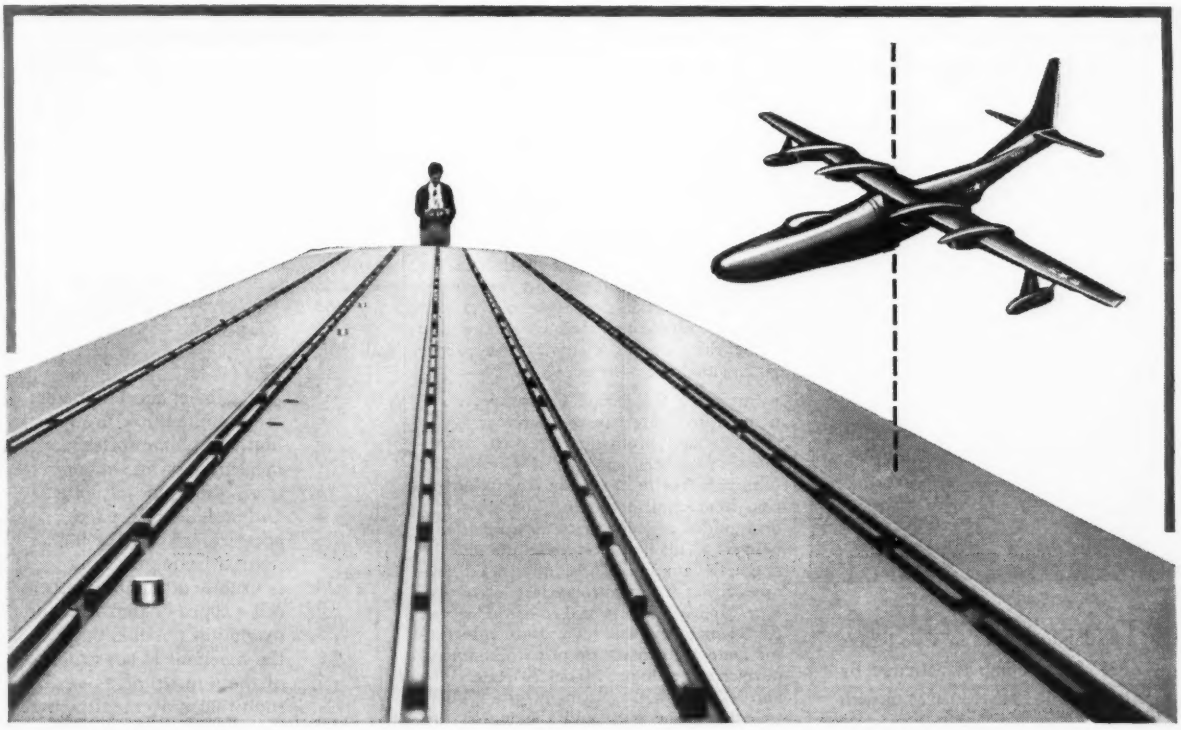
• **Sikorsky Aircraft Division, United Aircraft Corporation . . .** The production of a "large new military twin-engined helicopter" is planned for 1955. It is expected that a new plant, to be built in the northeastern section of Stratford, Conn., as soon as certain zoning regulations are satisfactorily cleared, will be available for this purpose.

• **Simmonds Aerocessories, Inc. . . .** A new type of Fiberglas rolled tubing for use in Simmonds Pacitron electronic fuel-gage systems has been developed. The new material incorporates Fiberglas cloth with a binding resin known as diallyl phthalate (DAP) and is said to provide a number of greatly improved working properties. The first use of this new material, which is expected to have wide application, is in the production of new two-tube tank units or sensing probes that, depending upon the installation, reportedly can reduce the overall weight of an aircraft fuel-gage system as much as 25 per cent. DAP was developed by Simmonds working in conjunc-

DOW

NAVY'S R3Y-1 FEATURES MAGNESIUM CARGO DECK

"Fastest flying boat" demonstrates extruded magnesium's combination of light weight and toughness for better flooring



MAGNESIUM EXTRUDED CARGO DECK SECTION *of the new Convair-built Navy R3Y-1 "Tradewind" now in production at San Diego. Magnesium provides the R3Y-1 with a tough, yet lightweight, easily installed cargo deck for heavy-duty service.*

In all its 40-year history, water-based aircraft has never been appraised in terms of speed or maneuverability. The big lumbering transports of past years were reputedly slow and cumbersome in flight. This was true primarily because of their great weight.

Today, however, Convair and the U. S. Navy present the "Tradewind" as the fastest flying boat in aviation history. Its turbo-prop engines provide a top speed of more than 350 mph . . . enable it to take off in 30 seconds with full load.

One factor that contributes greatly to the increased speed and easy handling of this giant seaplane is the extensive use of magnesium in its design. Take as an example, the cargo deck. It's made of magnesium ZK60A extrusion alloy. It's light in weight. (Magnesium is the world's lightest structural metal!) And it's strong and rugged enough for heaviest duty. This combination of qualities makes magnesium perfectly suited for this application.

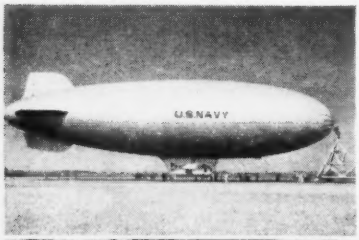
There are other instances, too, in this and in other aircraft, where magnesium has helped designers solve some of their weight and speed problems. Have you considered magnesium for your uses? For more detailed information, contact your nearest Dow sales office, or write directly to THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

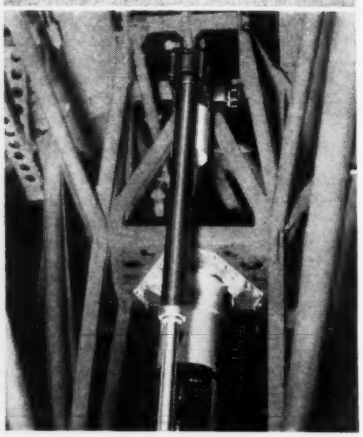
you can depend on DOW MAGNESIUM

DOW

ZP2K LANDING GEAR

Airborne Actuated





The landing gear in Goodyear's ZP2K Navy blimp is actuated by Airborne's R-534M1 LINEATOR with a 12½ in. stroke. Airborne electro-mechanical actuators are specified by Goodyear — and most other manufacturers of military aircraft — for two reasons: they provide high power output in a minimum of space, and they can be counted on, however rugged the conditions.

Dimensions and data on Airborne products for the aviation industry are given in the I.A.S. Aeronautical Engineering Catalog.

AIRBORNE
ACCESSORIES CORPORATION
1414 Chestnut Avenue
Hillside 5, New Jersey

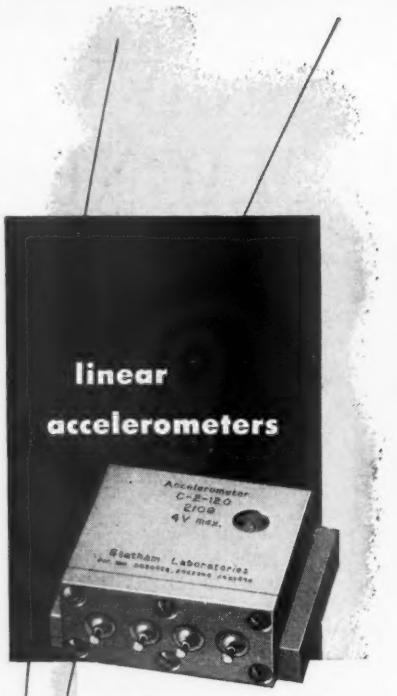
tion with Synthane Corporation and U.S. Polymeric Corporation.

• **Sperry Gyroscope Company, Division of The Sperry Corporation . . .** A working military system of a "major advancement" in automatic flight was shown at the recent National Air Show in Dayton, Ohio. This device, developed by Sperry under contract to Armament Laboratory, WADC, Air Research and Development Command, is designed for safer bad-weather approach and landings by either military or commercial passenger planes. Identified by the Air Force as a Beam Guidance Control, it will be known as the Radio Beam Coupler in a simplified commercial version that will follow the priority production of the military type. This new beam coupler becomes a part of the automatic pilot and is said to introduce more effective usage of the new VOR-omnirange beacons and other radio "tracks" on the principal air lanes of the world. According to the company, this device automatically compensates for wind drift while riding omnirange or other beams. When approaching airports on the localizer beam in fog, storms, or darkness, the coupler is said to detect promptly intersection with the glide path, shut off altitude control automatically, and transfer itself to glide-slope control. A new signal combination used in the coupler holds the aircraft firmly at the proper gliding angle, it is said.

• **Summers Gyroscope Company . . .** A new Rate Integrating Detector, Model 97, has been developed by Summers. Now in production, this new model is tumble-free in operation, thus giving a consistent single-axis control of an aircraft or a guided missile during any flight maneuver. This unit has no vacuum tubes or magnetic amplifiers. In addition to its application in an automatic control system, Model 97 is also said to be well suited for telemetering use. The Rate Integrating Detector is made up of two Summers-developed products, Model 70 Rate Gyro and Model 120 Integrating Motor. These two units, the gyro and the motor, are coupled within a 4.75- by 5.75- by 4.5-in. case and weigh 3 lbs.

• **Thompson Products, Inc. . . .** A contract was recently awarded to Thompson to build and operate a jet-engine test facility to be located on the Lake Erie shore in Perry Township, Ohio, about 20 miles east of the company's Tapco Plant. This facility, designated as a Naval industrial reserve aircraft plant, will be used for the evaluation of jet-engine materials, components, and accessories of the latest design. It will accommodate anticipated future engines of considerably higher thrust than those in use in today's aircraft. The company has stated that it has no intention of developing a jet engine of its own.

• **United Aircraft Corporation . . .** A college scholarship program for the sons of United Aircraft employees has been announced. Under the provisions of this plan, ten scholarships will be awarded each year, following extensive competitive tests, for the study of engineering or allied sciences at an accredited college or university offering a standard 4- or 5-year course



Linear accelerometers are manufactured by Statham Laboratories for measurement in ranges from ±0.5g to ±1,000g. Unbonded strain gage accelerometers have higher natural frequency than is usually attainable with other types of pickoffs. For maximum possible output, the mechanical construction of these instruments is such that movement of the suspended mass produces a change of resistance of all four arms of the complete balanced bridge. The resistive nature of the bridge permits the use of these accelerometers in either A.C. or D.C. circuits.

Please request Bulletin No. 4.0.

Statham
LABORATORIES
• Los Angeles 64, Calif.

The Ideal Gift for 1953

A Complete Record of U. S. Aviation Industry and Achievements since 1903

TYPICAL PRESS COMMENTS

"It is the best year-by-year chronology of American aviation history in print. The photo selection is excellent and the annual summaries of aviation firms, many of whom have long since vanished, makes fascinating study."

—Aviation Week

". . . a publishing feat unusual in several ways . . . Its 178 pages are filled with priceless pictures from Kitty Hawk to Muroc."

—New York Times

". . . (a book) to study and enjoy—and ponder."

—AP Newsfeatures

". . . It is one of the best books on the subject that has come to the attention of this corner in a long while."

—Los Angeles Examiner

". . . probably the most complete chronology of aviation ever published in the United States."

—Los Angeles Times

- ***Important facts about who did what—and when***
- ***600 illustrations of the various airplanes built***

Here is a gift that can be appreciated by your friends and your own youngsters for a lifetime. Order those extra copies now. The supply is limited.

INSTITUTE OF THE AERONAUTICAL SCIENCES
2 E. 64th Street, New York 21, N.Y.

Publications Dept.

Gentlemen:

Enclosed is $_____* for _____cop(y)ies of "Fifty Years of Flight." Please forward at once to:

Name _____

Address _____

_____

DEPARTMENT OF THE INTERIOR
BUREAU OF MINES LIBRARY

*** $5.00 per copy, postage prepaid (Less 10% Discount to IAS Members). Special discounts quoted on quantity orders.**

leading to a bachelor's degree in those subjects. Each of these scholarships provides payment of tuition and laboratory fees, as well as $500 a year. The student is free to select his own school. If, however, the one he chooses is a privately endowed institution, United will make an unrestricted gift to the college of $500 a year in recognition of the fact that the tuition fees of such institutions represent only a portion of the actual cost of a student's education.

• **Westinghouse Electric Corporation . . .** According to a recent Navy-Westinghouse announcement, a new high-power low-weight axial-flow turbojet engine, the J46, has been developed and placed in production. The J46, an outgrowth of the Westinghouse J34 jet engine, measures about 16½ ft. in length and less than 3 ft. in diameter. It was stated that Westinghouse has discontinued further development work on advanced models of the J40 engine in order to concentrate the corporation's full development and research facilities on perfecting new models of the J46. Production of the current model of the J40, now being manufactured at the Westinghouse plant in Kansas City, Mo., is being continued.

IAS Sections

Buffalo Section

George B. Melrose, Jr., *Secretary*

The eighth and final meeting of the 1952–1953 season was held on June 17 in the Crystal Room of the Touraine Hotel. This meeting marked the end of a successful series of programs by the Buffalo Section. The details and arrangements for the meeting were directed by Pete D'Anna, June Program Chairman. An attentive audience of approximately 45 members and guests was present.

The subject for the meeting was "The Airship in Modern Aviation" and was ably covered by Dr. R. S. Ross, of Goodyear Aircraft Corporation. The speaker discussed the history and present tactical uses of lighter-than-air craft. He pointed out that the nonrigid airship is today the main antisubmarine air weapon and that a considerable number of airships are currently being manufactured for this purpose. Some of the main advantages of the airship are its great range and endurance, small turn radius, and relative indestructability. Dr. Ross's talk was illustrated by a series of slides that showed (1) the step-by-step procedure of erecting an airship and (2) the many research projects that have been carried out at Goodyear. These diversified projects include the design and manufacture of canopies, rocket-booster casings, sandwich panels, fabric fuel tanks, offshore oil-well platforms, computers, and gunnery targets. The speaker also discussed the experiments being performed at the "fish tunnel" in order to investigate the as yet inexplicable low drag of our piscatorial friends.

Dr. Ross concluded his most interesting talk with a sound film on lighter-than-air ships, *The IIistory of Rigid Airships.* The movie depicted the entire history of rigid airships.

A discussion period followed the program.

San Diego Section

Earl R. Hinz, *Secretary*

August may normally be a month of vacationing for the working world, but the San Diego Section kept to the helm, and more than 300 members and guests participated in three technical meetings held in the IAS Building. The first meeting was on August 6, and the general topic was "Fatigue in Aircraft Structures."

Roy Miller, Design Specialist at Consolidated Vultee Aircraft Corporation, set the stage by illustrating the basic causes of fatigue failure in aircraft parts. Fatigue life is determined by the mean stress level, the ratio of maximum to minimum stress in the working cycle, the temperature, and the notch sensitivity of the material. One common means of increasing fatigue life is used in the prestressed bolt principle. Here, the mean stress level is raised, but the stress ratio is reduced with a resultant gain in fatigue life. Mr. Miller used slides to illustrate the stress raiser factors common to holes, notches, fillets, etc., which hasten the fatigue failure of structural components.

Garner Green, Chief Structures Engineer at Convair, continued the fatigue discussion with an analysis of problems involved in predicting the life of aircraft. Because the fatigue life of metals is quoted as so many cycles at a particular stress level and temperature, it is necessary for the designer to estimate the number of cycles of stress reversal to which a particular part will be subjected. Briefly, this requires predicting the number of landings for an aircraft, total revolutions of the wheels under load, number and size of gusts, maneuvering loads, etc.,—truly a formidable problem.

In the design of aircraft components, certain criteria can be followed which will prolong structural life. Locally concentrated masses, such as access doors, should be avoided in skin panels; stress raisers should be eliminated in structural members; and the probability of secondary bending loads in eccentric designs should be thoroughly investigated.

▶ On August 14, a second technical meeting was held at which Dr. Fred L. Whipple, of the Harvard College Observatory, spoke on the subject "Photographic Meteor Research." Dr. Whipple described in some detail the equipment and methods he is using in the study of the upper atmosphere.

The basic tool in this research is the Super Schmidt Meteor Camera. This instrument, designed primarily for meteor studies, incorporates such features as a spherical surface film and an F.63 lens. Presently, he is using a pair of these cameras spaced 18 miles apart and located in the vicinity of Las Cruces, N.M., for his meteoric and atmospheric research. His observations of meteors and meteor trains has added greatly to the knowledge of winds and other atmospheric conditions at great altitudes.

▶ The third technical meeting of the month took place August 20 with Ralph Kress, of the Solar Aircraft Company, presenting a paper on the development of an air-powered servo-actuator for jet-engine afterburners. The air-powered type of actuator was selected for this application because it could operate best in the 400°F. ambient temperature near the afterburner, would use a minimum amount of inflammable substance, and could get its energy directly from the turbojet compressor. An inherent problem with air drive, that of compressibility of the air, was overcome by using a small parallel hydraulic locking cylinder that provides a positive stop for the air cylinder.

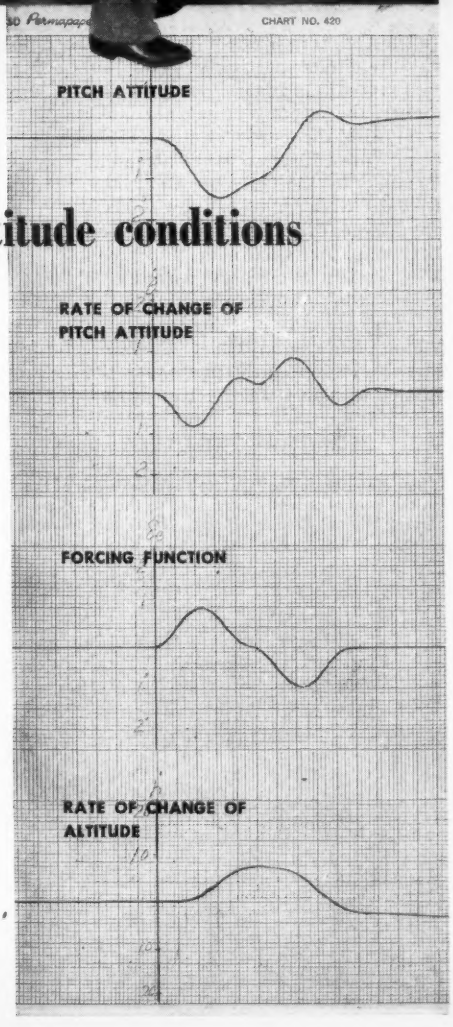
Control of the servo-cylinder is accomplished by a multipiston servo-valve that meters air and hydraulic fluid at the proper rates until the required actuator position is reached. Input power requirements to the servo-value do not exceed 5 lbs., and a 10,000-lb. thrust can be obtained from the air cylinder. Actuator speed is as high as 12 ½ in. per sec. with only a 0.2-sec. lag between input and output.

Following Mr. Kress's talk, movies were shown of recent flight tests of the Convair hydroski-equipped Sea Dart.

Wichita Section

D. J. Ahrens, *Outgoing Secretary*

The results of the election of officers are as follows: Chairman, Wilford



Four-channel recording correlates simulated jet bomber airspeed and altitude conditions

At Eclipse-Pioneer, engineers make good use of Sanborn 4-channel recording systems in conjunction with high precision analogue computers to establish performance criteria for automatic flight systems and components.

At other laboratories Sanborn Systems are being used to record such phenomena as: stress, strain, pressure, displacement, thickness, velocity, acceleration, current, voltage, temperature, torque, light, flow, force, load, position, rpm, radiation and tension.

SANBORN OSCILLOGRAPH RECORDING SYSTEMS HAVE MANY APPLICATIONS. They are used in a great many different fields where accurate and permanent graphic registration of almost any electrical phenomena (whose frequency range is zero to 100 cycles per second) is required.

Sanborn Systems are widely used because of the availability and ready interchangeability of amplifiers and preamplifiers, as well as such Sanborn advantages as: inkless recording in true rectangular coordinates, high torque movement, time and code markers and wide choice of paper speeds. In addition, a basic choice of systems, 1-, 2-, and 4-channels, provides a system to fulfill almost any laboratory requirements.

WRITE FOR CATALOG

Sanborn Company
INDUSTRIAL DIVISION
CAMBRIDGE 39, MASSACHUSETTS, U.S.A.

Pearce; Vice-Chairman, Elliott Merrill; Secretary, Charles Petrie; and Treasurer, Glenn McCormick. Tom Salter was named Representative on the Nominating Committee for Area Council Member. These men assumed the duties of office on September 2.

Student Branches

Academy of Aeronautics

Patrick Papp, *Chairman*

On July 22, an election of officers was held with the following results: Chairman, Patrick Papp; Vice-Chairman, F. J. Curasi; Corresponding Secretary, Ralph E. Silverman; Recording Secretary, William Gatehouse, and Treasurer, Frederick R. Bonardchuck.

Cal-Aero Technical Institute

James K. Carmody,
Secretary-Treasurer

The Cal-Aero Student Branch held its July dinner meeting at Pikes Restaurant in Glendale. After a fine dinner, the meeting proper got under way, with the newly elected officers being presented to the attending members by the Outgoing Chairman, Richard Stalder. The new officers are: James Bishop, Chairman; Sam L. Genian, Vice-Chairman; and James K. Carmody, Secretary-Treasurer.

Mr. Bishop then accepted the duties as emcee and presented Abe J. Victor, our genial Chief Engineer. Mr. Victor in turn presented the Branch with an attractive banner that had been donated by Robert Denny, Cal-Aero's President.

L. T. Long, Manager, Engineering Planning at United Air Lines Maintenance Base in San Francisco, was then introduced. Mr. Long gave a remarkable talk on engineering and engineering problems in the commercial air lines. The question-and-answer session that followed proved that Mr. Long had been well received by those persons attending.

Tri-State College

Ed Dwyer, *Secretary*

The officers for the present term are: Chairman, Irving Gray; Vice-Chairman, Thomas D. Owens; Secretary, Ed Dwyer; and Treasurer, Ray Bryan.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Lofkvist, H. E., M.S. Aeronautics, Chief, Research Engrg. Div., SAAB.

Owen, Paul Robert, B.Sc., Dir., The Fluid Motion Lab., Manchester Univ.

Transferred to Associate Fellow Grade

Austin, Frederick W., Resident Ch. Surveyor, Air Registration Bd. (Montreal).

Flesh, Edward M., Proj. Engr., McDonnell Aircraft Corp.

Meyer, John H., B.S. in C.E., Ch. of Struct., McDonnell Aircraft Corp.

Elected to MEMBER Grade

Auvray, Pierre M., Ch. of Engrg., Sabena.

Blair, Alan H., Military Sales Dept., Lockheed Aircraft Corp. (Burbank).

Ervin, Burl H., Ph.D. in Theoretical Mechanics, Sr. Aerodynamicist, Aircraft Div., R & D Labs., Rheem Mfg. Co.

Foss, Clifton T., B.S.E.E., Vice-President—Engrg., Arma Corp.

Greeniaus, H. J., B.A.Sc., Group Engr., Canadair, Ltd.

Harr, Phil I., B.S., Quality Control Mgr., Fairchild Aircraft Div. (Hagerstown).

Hill, Freeman K., Ph.D., Physicist, Applied Physics Labs., The Johns Hopkins Univ.

Hybertsen, Horace M., B.S. in Engrg., Design Engr., Sandberg-Serrell Corp. (Pasadena).

Jarmolow, Kenneth, S.B., Sr. Aerodynamics Engr., The Glenn L. Martin Co.

Jennings, Sidney J., B.Sc., Struct. Engr., North American Aviation, Inc. (Los Angeles).

Marriott, Edwin O., M.S., Aerodynamicist, Hughes Aircraft Co.

Orlik-Ruckemann, K., M.Sc., Sr. Research Engr., The Aeronautical Research Institute of Sweden.

Padden, Norman W., M.S.E.E., Service Engr., Aviation Engineering Corp.

Rassieur, W. T., M.S.Ae.E., Military Requirements Rep., Lockheed Aircraft Corp.

Transferred to MEMBER Grade

de Neufville, Albert, Ph.D., Asst. Prof. of Mechanics, Lehigh Univ.

Hilditch, William K., B. of Applied Science, Sr. Test Engr., A. V. Roe Canada, Ltd.

Joy, Warren, M.S. in Ae.E., Tech. Engr., Aircraft Requirements, AGTD, General Electric Co.

Kaufhold, Gerard W., B.S.Ae.E., Aero. Engr.—Production, Fighter Br., Procurement Div., AMC, Wright-Patterson AFB.

Mayes, James T., Jr., B.S.Ae.E., Sr. Design Engr. & Group Leader, Airplane Div., McDonnell Aircraft Corp.

Stephens, Robert R., B. of AeE., Design Engr., Aerodynamics, McDonnell Aircraft Corp.

Steuernagel, Carl A., B.S. in A.E., Sr. Engr., Missile & Radar Div., Raytheon Mfg. Co.

Thomson, Robert J., B.A.Sc.Ae.E., Section Head, Thermodynamics Section, A. V. Roe Canada, Ltd.

Elected to Associate Member Grade

Peterson, A. J., B. of M.E., Mgr., Govt. Projects, Goodyear Aircraft Corp.

Standing beside the Institute's reproduction of the Wright Brothers' 1903 airplane and holding the banner recently presented to the Cal-Aero Technical Institute Student Branch are the present Student Branch officers. *From left to right* are James Carmody, Secretary; James Bishop, Chairman; and Sam Genian, Vice-Chairman.

The Most Trusted Name in Ignition

safeguards every component part of your ignition system

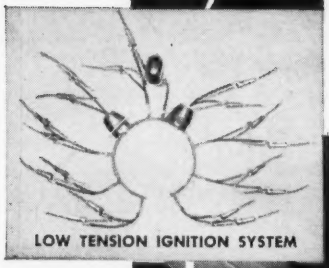
From Lindbergh's history-making flight to today's record breaking jets, Bendix ignition equipment has played a spectacular part in aviation progress.

While Bendix reputation in ignition has been spotlighted by scores of important engineering firsts, the industry's wide acceptance of Bendix ignition equipment has been built largely on the solid foundation of product excellence in every component part.

Just as a chain is no stronger than its weakest link, dependable ignition is the result of components designed and manufactured for unfailing efficiency.

That's why it pays to insist on Bendix ignition components for every part of your ignition system. Whether your requirement is for a better electrical connector, a complete new ignition system, or the famous Bendix Ignition Analyzer, you can be sure of quality performance when the good name of Bendix safeguards the reputation of every individual ignition product.

Why not consult our sales department for details?



LOW TENSION IGNITION SYSTEM

IGNITION ANALYZER

ELECTRICAL CONNECTOR

AVIATION PRODUCTS

Low and high tension ignition systems for piston, jet, turbo-jet engines and rocket motors . . . ignition analyzers . . . radio shielding harness and noise filters . . . switches . . . booster coils . . . electrical connectors.

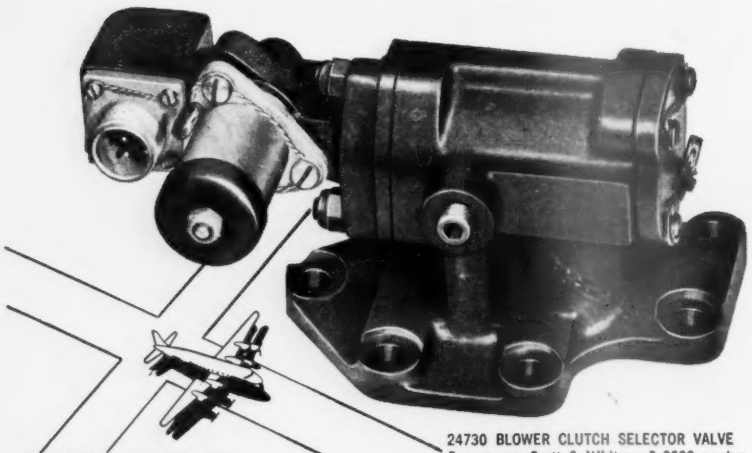
Bendix

SCINTILLA MAGNETO DIVISION

SIDNEY, NEW YORK

Export Sales: Bendix International Division
205 East 42nd St., New York 17, N. Y.

FACTORY BRANCH OFFICES: 117 E. Providencia Avenue, Burbank, California • Stephenson Building, 6560 Cass Avenue, Detroit 2, Michigan • Brouwer Building, 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 582 Market Street, San Francisco 4, California



24730 BLOWER CLUTCH SELECTOR VALVE
For use on Pratt & Whitney R-2800 engine.
Controls operation of two-speed supercharger. Electrical control is positive in action. Current failure returns valve to normal position, placing supercharger in low gear.
Weight: 2.2 lb.

ADEL

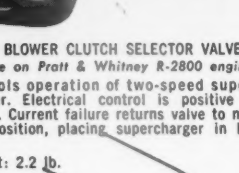
ENGINE ACCESSORIES

Precision-Built . . . Performance-Proved . . .

USED BY MAJOR AIRLINES AND AIRFRAME MANUFACTURERS

Valves and actuators you can specify with confidence. Provide fail-safe operation in case of electrical failure. Light weight.

Operating fluid: Engine Oil.
Duty: Continuous.
Solenoid: Single-coil, internally grounded.
Electrical Range: 18 to 30 volts dc.
Current drain: 0.5 amp at 24 volts.
Corrosion resistant construction.



24793 SUPERCHARGER CONTROL ACTUATOR
For use on Wright R3350-30 engine.
Provides positive control of two-speed supercharger with complete immunity to pressure surges in the operating fluid. Durable and dependable.
Weight: 1.75 lb.

26153 SUPERCHARGER CONTROL VALVE
For use on Pratt & Whitney R4360-63 engine.
Directs oil flow from pressure supply to high blower. Rated flow—9 gpm.
Built-in stamina provides dependable performance under extreme vibration conditions.
Weight: 1.9 lb.

25805 SUPERCHARGER ACTUATOR
For use on Wright R1820-103 engine.
Converts hydraulic pressure to mechanical push-pull actuation. Electrically controlled. Combines reliable operation with proven design . . . rugged construction.
Weight: 1.95 lb.

Write for new, descriptive Brochure containing detailed information on ADEL's line of Aircraft Equipment and facilities. Address ADEL DIVISION, GENERAL METALS CORPORATION, 10779 Van Owen St., Burbank, Calif.

ADEL produces a complete line of Aircraft HYDRAULIC & PNEUMATIC CONTROL EQUIPMENT, HEATER, ANTI-ICING & FUEL SYSTEM EQUIPMENT, ENGINE ACCESSORIES AND LINE SUPPORTS.

ADEL PREFERRED FOR AIRCRAFT THE WORLD OVER

DIVISION OF GENERAL METALS CORPORATION • BURBANK, CALIF. • HUNTINGTON, W. VA.

CANADIAN REPRESENTATIVE: RAILWAY & POWER ENGINEERING CORPORATION, LIMITED

Shugert, Richard F., B.Sc., Sr. Engr., Chase Aircraft Co., Inc.

Wood, Drury W., Jr., Capt., USMC; Operations Officer & Flight Instructor, Test Pilot Training, NATC (Patuxent River).

Elected to Technical Member Grade

Edmiston, James Mutch, B.S., Tech. Engr., Test Equipment Design Proj., AGTD, General Electric Co.

Equi, Eugene M., B.S. in Ae.E., Aero. Engr.—Engrg. Measurement & Analysis, Flight Test Div., General Electric Co.

Hasselbeck, Raymond A., B. Architectural Engrg., Struct. Test Engr., Bell Aircraft Corp.

Lutz, Elizabeth H., Design Engr. "B," Lockheed Aircraft Corp.

Transferred to Technical Member Grade

Andrews, Philip T., Sc.B. (Engrg.), Jr. Design Engr., Goodyear Aircraft Corp.

Bierley, Paul E., B. of Ae.E., Draftsman "A," North American Aviation, Inc. (Columbus).

Buckland, Robert E., B.S. in M.E., Assoc. Engr., Douglas Aircraft Co., Inc. (Long Beach).

Casaccio, Anthony, B. of Ae.E., Aerodynamicist, Republic Aviation Corp.

Chang, William, B. of Ae.E., Engr., Cessna Aircraft Co.

Cohen, Jerome L., B.A. Chem., Engrg. Draftsman "B," Republic Aviation Corp.

Cresci, Robert J., B. of Ae.E., Aerodynamics Engr., North American Aviation, Inc. (Downey).

Eklund, LaVerne G., B.S. in Ae.E., Grad. Student, California Institute of Technology.

Fahlstrom, Paul G., B. of AeE., 2nd. Lt., USMC.

Fleiss, Philip M., B. of Ae.E., Engr.—Struct., Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Fox, Gordon B., B.S. in Ae.E., Grad. Student, Massachusetts Institute of Technology.

Greenberg, Marvin, Tool Designer, Grumman Aircraft Engineering Corp.

Guadagnoli, Michael J., Weight Control Engr., Chance Vought Aircraft Div., United Aircraft Corp.

Hall, Joan F., B.Sc. (Engrg.), Jr. Engr., Piasecki Helicopter Corp.

Harris, Martin H., B. of Ae.E., Test Engr., Wright Aeronautical Div., Curtiss-Wright Corp.

Hertwig, Lee J., B.S. (Air Transportation), Test Engr., Wright Aeronautical Div., Curtiss-Wright Corp.

Heyner, F. Robert, B.S. in Ae.E., 2nd Lt., USAF; Pilot Training, Stallings AFB.

Hilton, John C., B.S., Aero. Engr., Allied Research Associates, Inc.

Howley, Donald L., B.S. in Ae.E., Aerodynamicist "C," North American Aviation, Inc. (Downey).

Johnson, Sherwood M., B.S. in Ae.E., Jr. Engr. "B," Stress Unit, Boeing Airplane Co. (Seattle).

Jordan, Jack R., B.S. (Air Transportation), First Officer-Copilot, North Central Airlines.

Keeton, Donald L., M.S. in Ae.E., Assoc. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Kelley, William J., B.S.M.E. (Aero.), Member, Stress Dept., Goodyear Aircraft Corp.

Kelly, Robert C., B.S., Engr., Flight Research Dept., Sikorsky Aircraft Div., United Aircraft Corp.

Khammash, Tariq B., B.S., Research Asst., Dept. of Aero. Engrg., The Pennsylvania State College.

Lennox, Stuart G., M.S.

Mager, Artur, Ph.D. (Aeronautics & Physics), Research Fellow—Jet Propulsion, California Institute of Technology.

Mandell, Donald S., B. of Ae.E., Stress Analyst "C," North American Aviation, Inc. (Columbus).

MacLeod, Gordon J., M.E., Engr.—Theoretical Analysis, Propulsion Research Corp.

Myers, George M., B. of Ae.E., Engr., Static Test Group, Grumman Aircraft Engineering Corp.

Nelson, Anthony L., B. of AeE., Jr. Engr.—Stress Analysis, Douglas Aircraft Co., Inc. (Long Beach).

Phillips, Edward H., B.S.M.E. (Aero.), Aero. Engr. in Training, Bell Aircraft Corp.

Poledna, James J., B.S., Jr. Detailer, Packard Motor Car Co.

Schoelerman, Duane B., B.S. in Ae.E., Aero. Engr., Aerodynamics Dept., Chance Vought Aircraft Div., United Aircraft Corp.

Smith, Lawrence F., B.S. in A.E., Aero. Engr., USAF (Tinker AFB).

Solverson, Robert R., Ph.D.

Tate, Stanley E., B.S., 2nd Lt., USAF; Student, USAFIT, Wright-Patterson AFB.

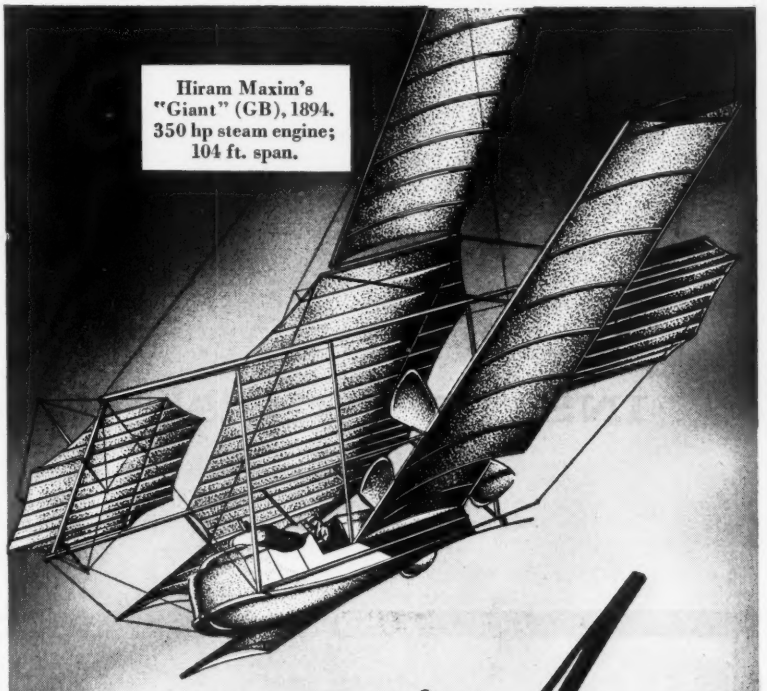
Trelewicz, Denis B., B. of Ae.E., 2nd Lt., USAF; Student Officer, Graham AFB.

Uppstrom, Richard L., B.S. in Ae.E., 2nd Lt., USAF.

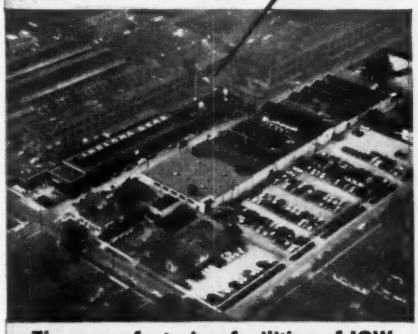
Voelker, Donald C., B.S. (Engrg.), Ens., USN.

Weir, Samuel G., B.S. in Ae.E., Aerodynamicist, Douglas Aircraft Co., Inc. (Long Beach).

Winneberger, Robert A., B.S., 2nd Lt., USAF.



...out of this came Aviation



The manufacturing facilities of IGW at Indianapolis

An industry whose tremendous growth has forced the continued expansion of the manufacturing facilities of many companies to feed this great industry's carnivorous appetite for production.

Indiana Gear Works is such a company—we began to produce precision parts for the aviation industry in 1933.

Today, twenty years later, we find ourselves continuing to increase our physical plant in order to gain the production capacity we need to consistently produce quality precision parts and assemblies.

INDIANA GEAR

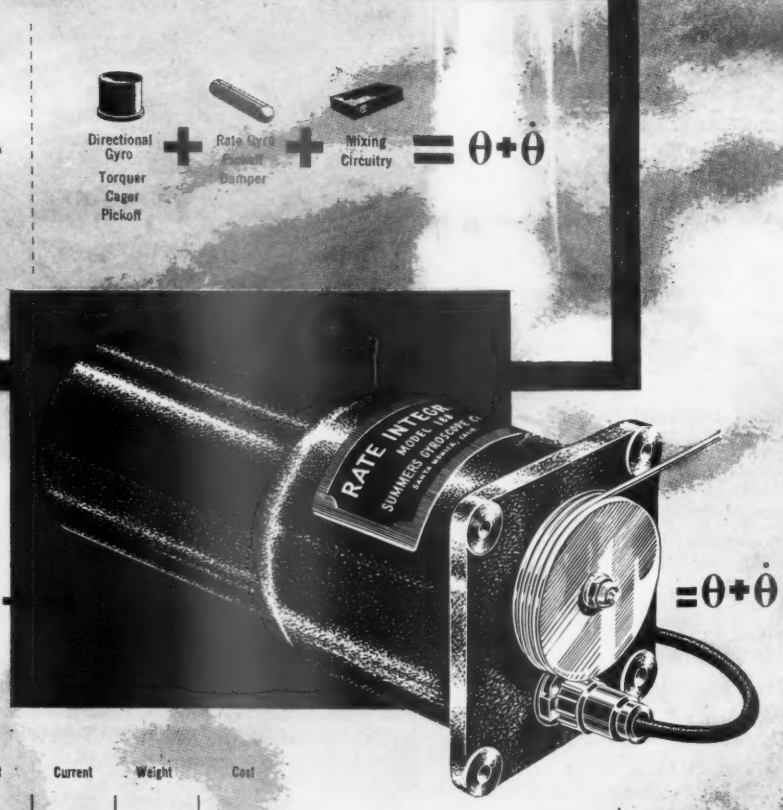
INDIANA GEAR WORKS, INC. • INDIANAPOLIS 7, INDIANA

NEW DISCOVERY IN INSTRUMENTATION

(reading time • 15 seconds)

Yesterday

TODAY..



	Reliability	Drift	Current	Weight	Cost
yesterday	.950	.5 /Min	3 amps	12 lbs.	
today	.999	.1/Min	.3 amps	3 lbs.	

SUMMERS GYROSCOPE COMPANY

2328 BROADWAY • SANTA MONICA, CALIFORNIA

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

Aerodynamics 72
Boundary Layer & Thermoaerodynamics 72
Fluid Mechanics & Aerodynamic Theory 72
Internal Flow 74
Performance 74
Stability and Control 74
Wings and Airfoils 74
Aeroelasticity 74
Aeronautics, General 74
Air Transportation 76
International Services 76
Airplane Design 76
Air Conditioning & Pressurization 76
Aviation Medicine 76
Computers 76
Education & Training 76
Electronics 76
Antennas 79
Circuits & Components 79
Communications 80
Construction Techniques 80
Electronic Controls 80
Electronic Tubes 82
Measurements & Testing 82
Transmission Lines 84
Wave Propagation 84
Equipment
Electric 84
Hydraulic & Pneumatic 84
Flight Operating Problems 84
Flight Safety & Rescue 84
Fuels & Lubricants 84
Lubricants & Lubrication 84
Gliders 86
Instruments 86
Flow-Measuring Devices 86
Machine Elements 88
Materials
Corrosion & Protective Coatings 88
Metals & Alloys 90
Metals & Alloys, Ferrous 90
Metals & Alloys, Nonferrous 93
Nonmetallic Materials 94
Testing 94
Mathematics 96
Meteorology 96
Military Aviation 96
Missiles 96
Navigation 96
Ordnance & Armament 96
Parachutes 96
Power Plants 96
Jet & Turbine 96
Rocket 96
Production 96
Metalworking 99
Production Engineering 100
Propellers 102
Reference Works 102
Rotating Wing Aircraft 102
Structures 102
Beams & Columns 104
Cylinders 104
Plates 104
Thermodynamics 106
Water-Borne Aircraft 106
Wind Tunnels & Research Facilities 106

II. BOOKS REVIEWED IN THIS ISSUE

Book Notes 109

Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada. Members of The Paul Kollsman Lending Library who are not Members of the Institute may borrow books and, in special cases, other research material. Members of the IAS may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.35 to members and Corporate Members ($0.45 to nonmembers) for each 8½- by 11-in. print and $0.40 to members and Corporate Members ($0.50 to nonmembers) for each 11½- by 14-in. print, plus postage. A minimum charge of $1.00 is made to nonmembers of the IAS.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $12 to $14 per 1,000 words, depending on the language. IAS members receive a 20 per cent discount on bibliographies and translations.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N Y.

PERFORMANCE in the Air
First IS PROVEN BY RESEARCH
CENTURY VIBRATION AND STRESS ANALYSIS INSTRUMENTS
This Century System provides all of the necessary equipment to measure vibration and stress-strain phenomena over a frequency range from 0 to 2000 cps. Can be used as a carrier system utilizing externally excited pick-ups or strain gages or a linear-integrating system utilizing self-generating pick-ups. Besides semi-permanent laboratory installation, is it ideally suited to mobile or airborne testing.
Century GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA
2946 Northern Blvd. Long Island City, N. Y.
4447 No. Bodine Philadelphia 40, Pa.
3406 W. Washington Blvd. Los Angeles 18, Calif.
238 Lafayette St. Dayton 2, Ohio
504 Interurban Bldg. Dallas, Texas
EXPORT OFFICE 199 Broadway N. Y. City

Aerodynamics

Experimental Investigation of the Effects of Support Interference on the Pressure Distribution of a Body of Revolution at a Mach Number of 3.12 and Reynolds Numbers from 2 × 10^6 to 14 × 10^6. L. Eugene Baughman and John R. Jack. *U.S., NACA RM E53E28*, Aug. 5, 1953. 18 pp.

Boundary Layer & Thermoaerodynamics

A New Method for Calculating Laminar Heat Transfer on Cylinders of Arbitrary Cross-Section and on Bodies of Revolution at Constant and Variable Wall Temperature. H. Schuh. *Stockholm, Kungliga Tekniska Högskolan, Inst. för Flygteknik, KTH-Aero TN 33*, June 12, 1953. 40 pp. 29 ref.

A Study of the Stability of the Incompressible Laminar Boundary Layer on Infinite Wedges. Neal Tetervin. *U.S., NACA TN 2976*, Aug., 1953. 41 pp.

Fluid Mechanics & Aerodynamic Theory

A Brief Survey of Progress on the Mechanics of Cavitation; An Addendum to DTMB Report 712, On the Mechanism and Prevention of Cavitation. Discussion and Author's Closure. . . . Phillip Eisenberg. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 842, 842A (NS 715-102)*, June, 1953. 24, 13 pp. 48 refs.

Characteristic Surfaces of the Equations of Motion for Non-Newtonian Fluids. Jerald Laverne Ericksen. *ZAMP*, July 15, 1953, p. 260.

The Deaeration of Water by a Sound Beam. Leonard Pode. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 854*, May, 1953. 20 pp.

Quantum Hydrodynamics and the Theory of Liquid Helium. J. M. Ziman. *Proc. Royal Soc. (London), Ser. A*, Aug. 25, 1953, p. 257. 13 refs.

Spreading of Supersonic Jets in Supersonic Streams. John G. Wilder, Jr., and Kenneth Hindersinn. *Aero. Eng. Rev.*, Oct., 1953, p. 54. Cornell Aero. Lab. experimental investigation, with an analysis of the effects of normal and oblique shock waves and of boundary displacement.

Measurement and Analysis of Turbulent Flow Containing Periodic Flow Fluctuations. William R. Mickelsen and James C. Laurence. *U.S., NACA RM E53F19*, Aug. 19, 1953. 45 pp. 13 refs.

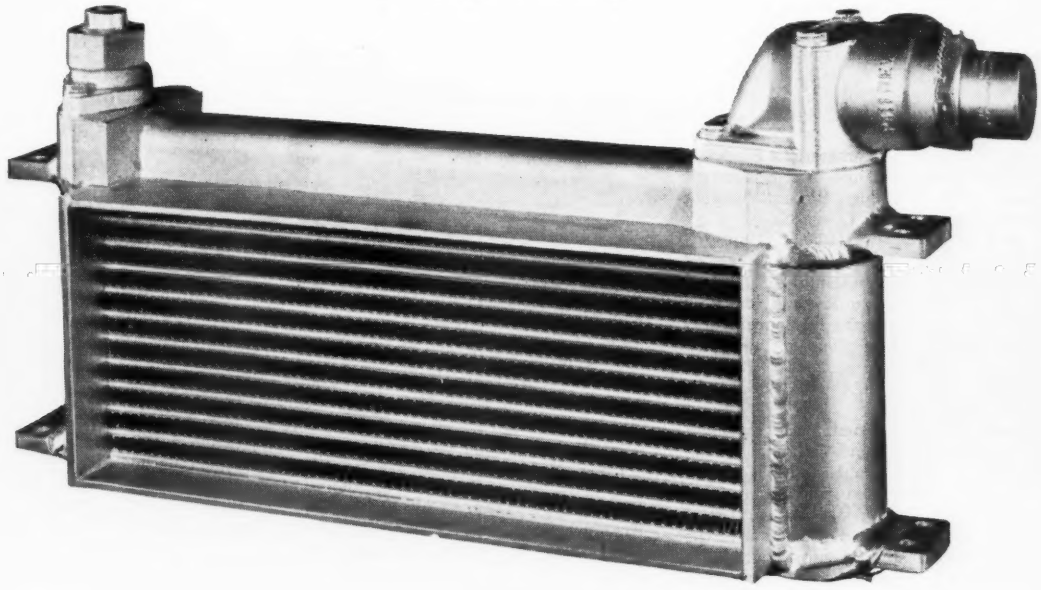
Vortex Streets in Incompressible Media. M. Z. Krzywoblocki. *Appl. Mech. Rev.*, Sept., 1953, p. 393. 198 refs. Review of the literature and phenomena characteristics.

Wave Motion in an Annular Tank. I. J. Campbell. *Philos. Mag. (7th Ser.)*, Aug., 1953, p. 845. Theoretical investigation of wave disturbances using water-whirling-arm equipment at the Admiralty Research Lab.

The Calculation of the Viscous Drag of Bodies of Revolution. Paul S. Granville. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 849*, July, 1953. 35 pp. 41 refs. Analysis includes rapid approximation methods for computing the growth of the laminar and turbulent boundary layers and an empirical criterion for locating the

Light . . . compact . . . rugged . . . reliable

Harrison plate-type aviation oil coolers are light in weight, compact in design, ruggedly built and reliable in performance under all operating conditions. These aluminum oil coolers are capable of withstanding internal pressures up to 400 psi. A thermostatically controlled valve by-passes the oil during the warmup.



The Harrison oil cooler is used in a wide variety of applications—to cool lube oil for compressor and turbine bearings of turbojet and turboprop engines . . . to cool helicopter engine and gearbox lubrication oil . . . to cool hydraulic system fluids in commercial and military aircraft.

Manufacturers of airframes and aircraft engines are invited to write for detailed performance data and specifications.

HARRISON
RADIATOR
DIVISION

GENERAL MOTORS CORPORATION
LOCKPORT, NEW YORK

HARRISON

position of self-excited transition of low-turbulence flows.

A Laboratory Model Resembling the "Bishop-Wave" Phenomenon. Robert R. Long. *Bul. AMS*, May, 1953, p. 205. Experimental investigation of the flow of a three-layer system of immiscible fluids over an obstacle immersed in the lowest liquid.

On the Forces Acting on a Circular Cylinder Set Obliquely in a Uniform Stream at Low Values of Reynolds Number. S. Tomotika, T. Aoi, and H. Yosinobu. *Proc. Royal Soc. (London), Ser. A*, Aug. 25, 1953, p. 233. Extension of Taylor's hydrodynamic studies.

Supersonic Flow Past Oscillating Airfoils Including Nonlinear Thickness Effects. Milton D. Van Dyke. *U.S., NACA TN 2982*, July, 1953. 41 pp. 20 refs. Use of a smoothing technique in analysis to eliminate shock-wave considerations.

Internal Flow

Application of a Characteristic Blade-to-Blade Solution to Flow in a Supersonic Rotor with Varying Stream-Filament Thickness. Eleanor L. Costilow. *U.S., NACA TN 2992*, Aug., 1953. 36 pp.

Effect of Blade-Thickness Taper on Axial-Velocity Distribution at the Leading Edge of an Entrance Rotor-Blade Row with Axial Inlet, and the Influence of this Distribution on Alinement of the Rotor Blade for Zero Angle of Attack. John D. Stanitz. *U.S., NACA TN 2986*, Aug., 1953. 33 pp.

Luftkräfte an einem schwingenden Schaufelkranz kleiner Teilung. Heinz Söhngen. *ZAMP*, July 15, 1953, p. 267. In German. Vibration behavior study of a ring of axial compressor blades, with a method to evaluate the aerodynamic forces acting on thin slightly cambered blades arranged with small gap-chord ratio in a nonviscous incompressible medium.

Measurement of Air Flow. J. G. Withers. *The Engr.*, Aug. 21, 1953, p. 227. Pulsating-flow problems in the use of a surge-damping vessel.

On the Flow in a Gradually Diverged Open Channel. Masshi Hom-ma and Sukeyuki Shima. *Japan Sci. Rev.*, Apr., 1952, p. 253. Experimental study and computational results.

Pressure Distributions on the Blade of an Axial-Flow Propeller Pump. D. A. Morelli and R. D. Bowerman. *Trans. ASME*, Aug., 1953, p. 1007. Application of the airfoil theory, with experimental data covering impeller design and tests.

A Theory on Cascades Built up of Arbitrary Blade Sections. Masa-aki Shirakura. *Japan Sci. Rev.*, Apr., 1952, p. 243. 11 refs. Mapping method for obtaining a potential flow passing through a cascade of small pitch-chord ratio and through a blade section of large camber and thickness; numerical examples and results.

Wirbelsysteme in Schaufelgittern und Turbomaschinen. Walter Traupel. *ZAMP*, July 15, 1953, p. 298. In German. Survey of the phenomenon of vortex systems in fluid flow past a row of deviating turbomachine blades.

Comparison of Secondary Flows and Boundary-Layer Accumulations in Several Turbine Nozzles. Milton G. Kofskey, Hubert W. Allen, and Howard Z. Herzig. *U.S., NACA TN 2989*, Aug., 1953. 58 pp. Flow visualization study and detailed flow measurements.

Heat Transfer in a Nozzle at Supersonic Speeds. O. A. Saunders and P. H. Calder. *IME Proc. (B)*, No. 6, 1952, p. 232; Communications, p. 237.

Heat Transfer to Low Pressure Sprays of Water in a Steam Atmosphere. I—The Mechanics of the Spray. II—Heat Transfer. Sidney Weinberg. *IME Proc. (B)*, No. 6, 1952, pp. 240, 246; Communications, p. 253. 14 refs. Investigation of the flow of water as a film and in drops from different nozzles and of related heat-transfer coefficients; application to air conditioning, vacuum cooling, and other temperature-control equipment.

Recherche d'Approximations des Équations Régissant les Écoulements des Gaz. Applications aux Tuyères Planes. M. Fenain. *La Recherche Aéronautique*, May-June, 1953, p. 11. 18 refs. In French. Investigation of approximations of equations governing the subsonic-transonic flow of gases, utilizing two methods; application to the analysis of flows in nozzles.

Performance

An Analysis of Normal-Acceleration and Airspeed Data from a Four-Engine Type of Transport Airplane in Commercial Operation on an Eastern United States Route from November 1947 to February 1950. Thomas L. Coleman and Paul W. J. Schumacher. *U.S., NACA TN 2965*, Aug., 1953. 27 pp. 13 refs.

Some Measurements of Landing Contact Conditions of Transport Airplanes in Routine Operations. Norman S. Silsby, Emanuel Rind, and Garland J. Morris *U.S., NACA RM L53E05a*, July 22, 1953. 8 pp.

Use of Corrected Non-Dimensional Parameters for Standardizing Jet Aircraft Rate-of-Climb Data. Paul E. Shoemacher. *USAF FTC TR 52-13*, May, 1953. 37 pp.

Stability & Control

Estimation of Forces and Moments Due to Rolling for Several Slender-Tail Configurations at Supersonic Speeds. Percy J. Bobbitt and Frank S. Malvestuto, Jr. *U.S., NACA TN 2955*, July, 1953. 71 pp. 13 refs. Method of analysis based upon an application of conformal-transformation techniques.

Procedure for Determining Aircraft Stability Derivatives from the Frequency Response by Use of Frequency Function Templates. Evert D. Wilmoth. *USAF FTC TR 52-31*, May, 1953. 45 pp.

Réglage Dynamique des Maquettes par Déplacement de Masses. René Dimitroff. *La Recherche Aéronautique*, May-June, 1953, p. 41. In French. Dynamic control of models by the displacement of mass to calculate variations of moments of inertia.

Techniques for Calculating Parameters of Nonlinear Dynamic Systems from Response Data. Benjamin R. Briggs and Arthur L. Jones. *U.S., NACA TN 2977*, July, 1953. 67 pp. 17 refs.

Wings & Airfoils

The Aerodynamic Characteristics of an Aspect-Ratio-20 Wing Having Thick Airfoil Sections and Employing Boundary-Layer Control by Suction. Bennie W. Cocke, Jr., Marvin P. Fink, and Stanley M. Gottlieb. *U.S., NACA TN 2980*, Aug., 1953. 63 pp. Effects of varying suction flow rate, suction-slot configuration, wing surface condition, flap deflection, and Mach Number.

Profils Laminaires pour Vitesses Subsoniques. Robert Legendre. *La Recherche Aéronautique*, May-June, 1953, p. 9. In French. Calculation of laminar airfoil sections adapted to a Mach Number of 0.7.

Transonic Flow Past a Wedge Profile with Detached Bow Wave. I—General (Analytical) Method and Final Results; Description of Flow Field. II—Details of Analysis. Walter G. Vincenti and Cleo B. Wagoner. (*U.S., NACA TN 2339, 2588*, 1951.) *U.S., NACA Rep. 1095*, 1952. 30 pp. 44 refs. Supt. of Doc., Wash. $0.30.

Aeroelasticity

Correlation of Calculation and Flight Studies of the Effect of Wing Flexibility on Structural Response Due to Gusts. John C. Houbolt. *U.S., NACA TN 3006*, Aug., 1953. 14 pp.

Méthodes Simplifiées pour l'Estimation Rapide des Vitesses de Flutter. G. de Vries. *La Recherche Aéronautique*, May-June, 1953, p. 29. In French. Qualitative flutter analysis based on two simplified methods for the rapid calculation of critical speeds of an aircraft; some basic physical and structural factors, including the rigidity of torsion and bending.

On Interaction of Non-Linear Oscillations. N. Minorsky. *J. Franklin Inst.*, Aug., 1953, p. 147. Study of the existence, stability, and topological rules of selection between several oscillations; investigation by a stroboscopic method of results applying to the differential equation:

$$\ddot{x} + e(x^2 - 1)\dot{x} + [1 + (a - cx^2)\cos 2t]x = 0$$

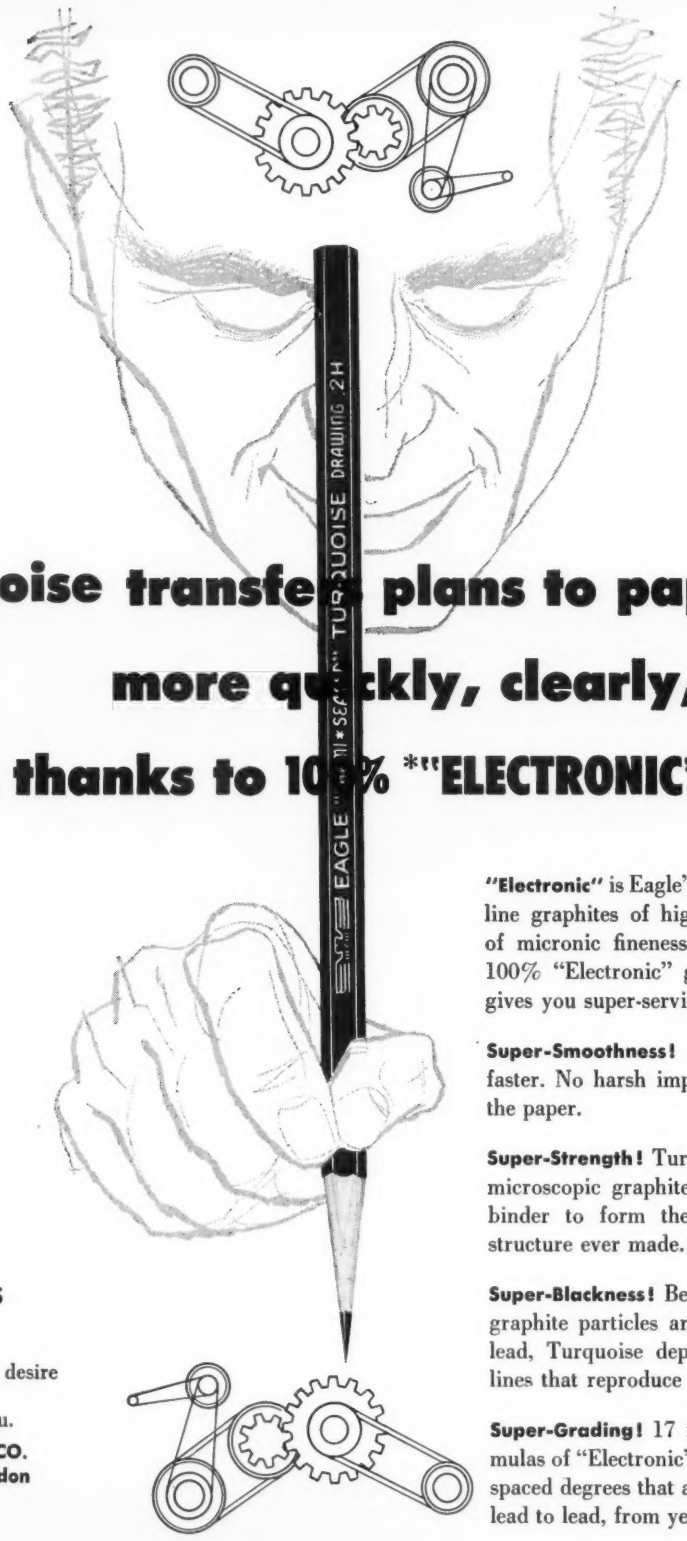
Errors Introduced by Finite Space and Time Increments in Dynamic Response Computation. Samuel Levy and Wilhelmina D. Kroll. (*Research Paper 2431.*) *U.S., NBS J. Res.*, July, 1953, p. 57. Investigation of the accuracy and stability of numerical integration methods for transient vibration analysis.

The Nature of Solutions of a Rayleigh-Type Forced Vibration Equation with a Large Coefficient of Damping. Paul Brock. *J. Appl. Phys.*, Aug., 1953. p. 1004.

Aeronautics, General

The Next Fifty Years. Hugh L. Dryden. *Aero Dig.*, July, 1953, p. 132. Survey of developmental and research potentialities.

Technical Review of the Paris Air Show. *Interavia*, No. 8, 1953, p. 385. Developmental survey of structural design and research covering new aircraft.



Turquoise transfers plans to paper more quickly, clearly, accurately . . . thanks to 100% *"ELECTRONIC" GRAPHITE

"Electronic" is Eagle's trade name for a blend of crystalline graphites of highest purity, reduced to particles of micronic fineness in our patented Attrition Mill. 100% "Electronic" graphite in every Turquoise lead gives you super-service in four important ways:

Super-Smoothness! Turquoise leads are smoother, faster. No harsh impurities slow your line or scratch the paper.

Super-Strength! Turquoise points don't crumble. The microscopic graphite particles combine with the clay binder to form the strongest, longest-wearing lead structure ever made.

Super-Blackness! Because millions more of super-fine graphite particles are compacted in every inch of its lead, Turquoise deposits denser, blacker, more even lines that reproduce to perfection.

Super-Grading! 17 individual, exactly controlled formulas of "Electronic" graphite and clay make 17 evenly spaced degrees that are uniform from end to end, from lead to lead, from year to year.

SEND FOR FREE SAMPLES
Just drop us a note, naming the degrees you desire and the dealer who supplies you.

EAGLE PENCIL CO.
New York • London
Toronto

*"CHEMI-SEALED" (Super-Bonded)
*EAGLE *TURQUOISE DRAWING PENCILS AND LEADS
with 100% *"Electronic" Graphite

power plants, and components, with charts, tables, and drawings.

The Wright Reproduction. Beverly A. Dodge. *Aero. Eng. Rev.*, Oct., 1953, p. 24. The West Coast cooperative project for the exact reproduction of the original Wright aircraft.

Air Transportation

Commercial Air Transportation in the Union of Soviet Socialist Republics. J. Wilford Rizika. *J. Air Law & Commerce*, Spring, 1953, p. 127. Development and potentialities of future civil aviation in the U.S.S.R.

A Critique of the C.A.A. Studies on Air Traffic Generation in the United States. G. Roger Mayhill. *J. Air Law & Commerce*, Spring, 1953, p. 158.

Effect of Engine Weight, Drag, and Fuel Consumption on the Direct Operating Cost of a Commercial Aircraft. J. E. Steiner. (*Paper, SAE Annual Meeting, Detroit, Mich., Jan. 12–16, 1953.*) *Esso Air World*, May-June, 1953, p. 148. Payload vs. range and other cost and design factors in use of reciprocating, turboprop, and turbojet engines.

Optimum Conditions for the Operation of Airline Aircraft. Alan H. Stratford. *J. RAeS*, Aug., 1953, p. 524. Revenue potential and flight costs.

A Variable Fuel Reserve Policy. J. Vivian. *J. Inst. Navigation*, July, 1953, p. 255. Operational control of high fuel consumption as related to pay loads in air-line service.

International Services

The Air Traffic Language; French and Spanish Translations of Definitions in the IATA Traffic Glossary. *IATA Bul.*, Mid-Year, 1953, p. 55.

The Development of International Performance Standards for Commercial Aircraft. A. Münch. *Interavia*, No. 8, 1953, p. 412.

The Jet Transport and the North Atlantic. D. A. Brice. *Aeronautics*, Aug., 1953, p. 32. Fuel conservation, meteorological, and other problems.

Scandinavian Airlines System Cooperation in the Air. Robert A. Nelson. *J. Air Law & Commerce*, Spring, 1953, p. 178.

Some Problems in the Development of Air Transport in West Africa. Hubert Walker. (Ninth British Commonwealth and Empire Lecture.) *J. RAeS*, Aug., 1953, p. 477. Includes airport, meteorological, telecommunications, traffic control, passenger and cargo routing, and other problems.

Airplane Design

Bell X-5; First Revelation of Details of World's First Variable-Sweep Research Airplane. James A. O'Malley, Jr., and Robert J. Woods. *Aero Dig.*, Aug., 1953, p. 29, cutaway drawing. Design characteristics and flight test technical data.

The Development of "Probe and Drogue" Refuelling. P. S. MacGregor. *J. RAeS*, Aug., 1953, p. 510, cutaway drawings. Analysis of equipment designs and procedural requirements.

The Economics of the Comet Series 3; High Speed Means Lower Cost per Ton Mile. *de Havilland Gazette*, Aug., 1953, p. 126. Range, payload, work capacity, maintenance requirements, and other characteristics compared with a piston-engined aircraft.

Flying the Lockheed T-33. John Fricker. *The Aeroplane*, Aug. 21, 1953, p. 225. Performance and other technical details.

Heron Performance Improved; All-Up Weight Raised to 13,000 lb. *de Havilland Gazette*, Aug., 1953, p. 130. Graphic analysis of performance which covers cruising range, fuel consumption, payload capabilities, and other economic and technical characteristics.

Jet Aircraft Operation. R. L. Loesch and J. B. Fornasero. *Aero Dig.*, Aug., 1953, p. 84. Comparison with aircraft using other types of engines; design simplification factors; climb and cruise conditions and other performance data.

The Basic Problem of Undercarriage Geometry; The Definition and Checking of the Pivot Axis about which the Undercarriage Rotates. L. S. Bialowski. *Aircraft Eng.*, Aug., 1953, p. 236.

Fifty Years of Undercarriage Development. I, II. *The Engr.*, Aug., 21, 28, 1953; pp. 243, 275. Evolution of design landing gear to the present; application of the fixed and retractable oleo-pneumatic leg installations.

Optimum Design Considerations for Aircraft Wing Structures. Aaron L. Kolom. *Aero. Eng. Rev.*, Oct., 1953, p. 31.

Air Conditioning & Pressurization

Automatic Cabin Temperature Control. R. D. Weber. *Aero Dig.*, Aug. 1953, p. 78. Design of a fully thermostatically controlled system.

Cabin Air Conditioning in High Speed Flight. F. V. Davies. *Gt. Brit., RAE TN Aero. 2196*, Jan., 1953. 31 pp.

de Havilland Cold-Air Unit. *de Havilland Gazette*, Aug., 1953, p. 136. Design features and installation details.

Aviation Medicine

The Action of Antihistamine Solutions Applied to the Mucous Membranes of the Nose. Leslie N. Gay and Leroy M. Polvogt. *USAF SAM Project 21-1208-0010 Rep. 1*, May, 1953. 5 pp.

Effect of Oxygen Deficiency and Various Other Factors on Color Saturation Thresholds. Ingeborg Schmidt and Abraham G. A. Bingel. *USAF SAM Project Rep. 21-31-002*, Apr., 1953. 21 pp. 22 refs.

The Effects of Certain Motion-Sickness Preventives Upon Navigator Proficiency. Robert B. Payne, Dale R. Osier, and P. A. S. Tomlinson. *USAF SAM Project 21-1601-0004 Rep. 1*, May, 1953. 8 pp.

The Effects of Motion-Sickness Preventives Upon Certain Perceptual-Motor Components of the Pilot's Task. Robert B. Payne and George T. Hauty. *USAF SAM Project 21-1601-0004 Rep. 3*, May, 1953. 4 pp.

Evaluation of the Grether Self-Administering Color Vision Test. Ingeborg Schmidt. *USAF SAM Spec. Project Rep.*, Mar., 1953. 10 pp.

New Applications for Electric Heat. R. F. Sambleson. *G-E Rev.*, Sept., 1953, p. 28. Applications include special clothing and equipment for the USAF.

Psychiatric Screening of Flying Personnel; Research on the Cornell Index. John R. Barry and Gordon H. Raynor. *USAF SAM Project 21-0202-0007 Rep. 2*, May, 1953. 26 pp. 48 refs.

Computers

Coding by Feedback Methods. B. D. Smith. *Proc. IRE*, Aug., 1953, p. 1053. Basic principle of analog-to-digital conversion devices.

An Exploration of Numerical Filtering Techniques. John T. Fleck and William D. Fryer. *Cornell Aero Lab. Rep. XA-869-P-1*, May 1, 1953. 79 pp. 10 refs. Application to analog systems and recommendations for development of methods.

Solving Automotive Problems with Automatic Computers; A New Tool for Engineers. Arvid W. Jacobson and Harry D. Huskey. *Auto. Ind.*, Sept. 1, 1953, p. 52. The Wayne University Computation Lab. program.

CRC 105 Computer. Richard E. Sprague. *Aero Dig.*, Aug., 1953, p. 48. Details of decimal digital differential analyzer; applications include study of missile performance.

I.B.M. C.P.C. Techniques. *Cornell Aero. Lab. Rep. 771-G-1*, Apr. 15, 1953. 21 pp. Analysis of the use of digital computers.

The Mercury-Delay-Line Storage System of the Ace Pilot Model Electronic Computer. E. A. Newman, D. O. Clayden, and M. A. Wright. (*IEE Measurements Sect. Paper 1527.*) *Proc. IEE, Part II*, Aug., 1953, p. 445. Details of a high-speed automatic digital computing machine for research and development, with an analysis of the circuit.

Optimale Rechengenauigkeit bei Rechenanlagen mit gleitendem Komma. Klaus Samelson and Friedrich L. Bauer. *ZAMP*, July 15, 1953, p. 312. In German. Investigation of the accuracy of automatic digital computers with floating binary point.

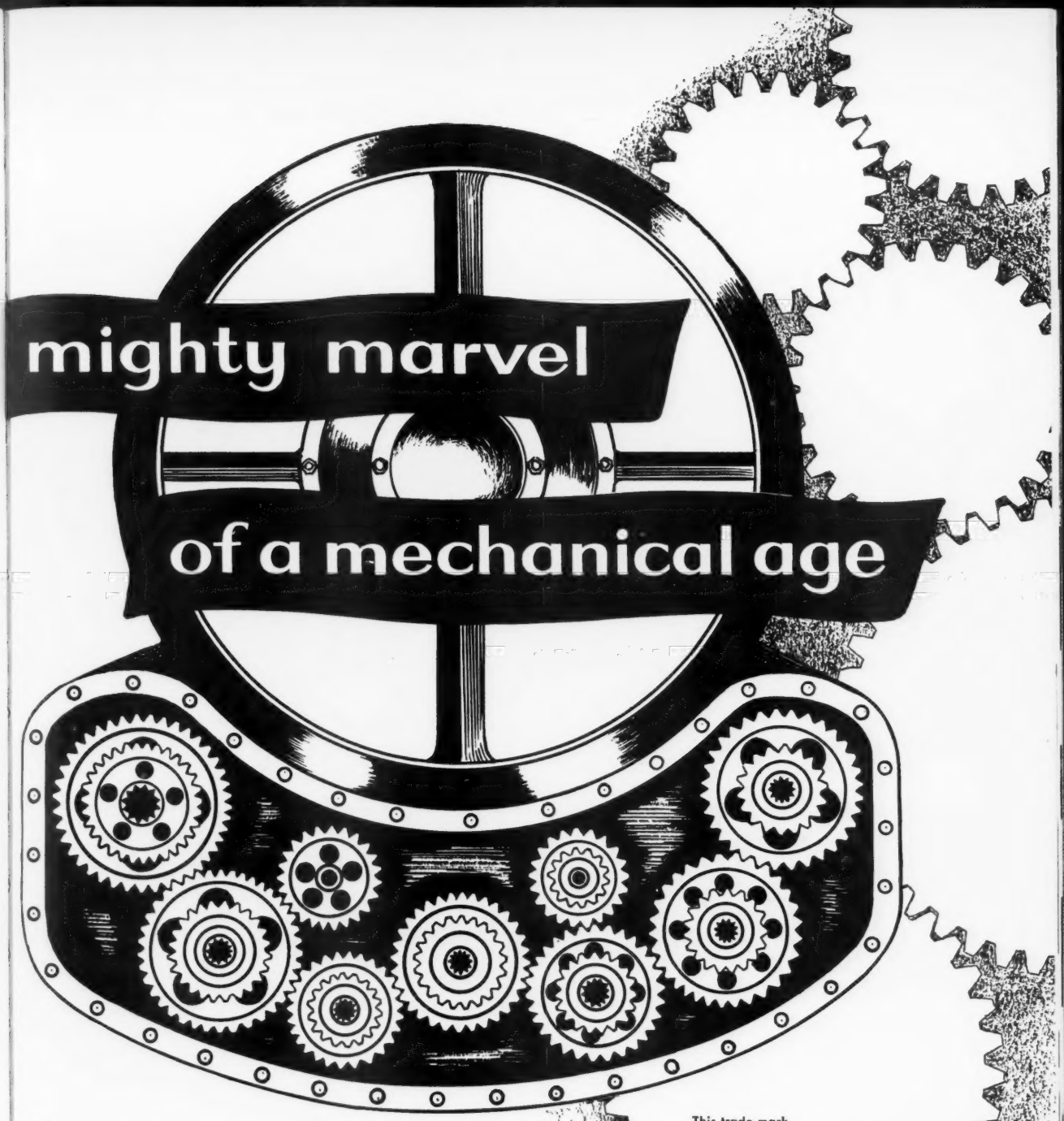
A Simple Decimal Counter Using Binary Units. W. C. G. Slatter. *Electronic Eng.*, Sept., 1953, p. 391. Code for expressing the integers 0–9 in four binary digits; modification of circuit for normal binary counting.

Education & Training

Air Crew Training. R. J. W. Brown. *Hunting Group Rev.*, Summer, 1953, p. 16. Development, design complexity, and cost factors covering procurement of equipment and operational problems.

Electronics

The Case of Charged Density Distribution Versus Semi-Permanent Polarization as a Basis for Electret Behavior. W. F. G.



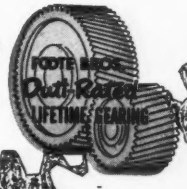
Here is the drive for a jet engine that translates high turbine speed into exactly the correct speed to drive generators, fuel pumps and other accessories.

Packed with complex sets of high precision gearing, it must transmit a constant flow of power efficiently and dependably—must fit a confined space envelope and yet possess minimum weight.

This accessory drive, as well as many other aircraft drives, is produced in quantity by Foote Bros.

Foote Bros.' thoroughly experienced engineering staff stands ready to assist you in solving any drive problem, and Foote Bros.' complete manufacturing facilities offer you a logical source for any drive or mechanical unit.

This trade mark stands for the finest in industrial gearing



FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard • Chicago, 9, Illinois

Imperial

THE *Finest*

TRACING CLOTH

Imperial is known in drafting rooms all over the world as the traditional quality tracing cloth.

With the background of decades of experience, its makers have pioneered in modern improvements to maintain Imperial as the finest tracing cloth made.

High Temperature

BOLTS

• It takes tough, heat-resistant bolts to withstand the temperatures of modern jet engines. Today, The H. M. Harper Company is manufacturing fastenings of such modern high temperature alloys as Discaloy, Refractaloy, A-286, and stainless steel. If you require fastenings to withstand high temperatures, corrosion, excessive wear, or other extreme conditions, call Harper. Information on request.

THE H. M. HARPER COMPANY
AERO DIVISION
8282 Lehigh Avenue
Morton Grove, Illinois

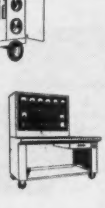
Specialists in High Temperature Fastenings of
REFRACTALOY
A-286
INCONEL
DISCALOY
HASTELLOY
19-9-DL
GREEK ASCALLOY
TITANIUM
STAINLESS STEEL

HARPER

AERO DIVISION

United

ELECTRICAL TESTING EQUIPMENT



Electrical components on aircraft, portable power units, ordnance vehicles and guided missiles are tested rapidly and accurately with United Test Equipment.

Our products meet the most critical requirements of the Armed Forces of the U.S., electrical equipment manufacturers and major airlines of the world.

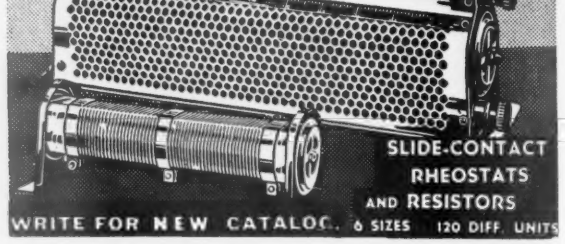
Your inquiries are cordially invited—promptly answered.

UNITED ELECTRICAL TESTING EQUIPMENT

UNITED MANUFACTURING CO.
HAMDEN 14 CONNECTICUT

REX RHEOSTAT CO.

BALDWIN L. I., N. Y.



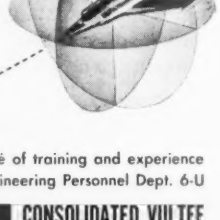
SLIDE-CONTACT RHEOSTATS AND RESISTORS

WRITE FOR NEW CATALOG. 6 SIZES 120 DIFF. UNITS

Top-Notch

SENIOR AERONAUTICAL ENGINEER

in AIRCRAFT or MISSILE AUTOMATIC CONTROL



wanted by

Send resumé of training and experience to M. L. TAYLOR, Engineering Personnel Dept. 6-U

CONVAIR

IN FRIENDLY FORT WORTH, TEXAS

CONSOLIDATED VULTEE AIRCRAFT CORP.
FORT WORTH, TEXAS

Swann. *J. Franklin Inst.*, Aug., 1953, p. 167.

Computer Simulates Moving Radar Targets. W. B. Birtley. *Electronics*, Sept., 1953, p. 137. A dual-analog computer training technique to simulate interceptor and hostile aircraft on the radar indicator; operational theory and circuits.

Filters for Detection of Small Radar Signals in Clutter. Harry Urkowitz. *J. Appl. Phys.*, Aug., 1953, p. 1024. Investigation of the synthesis of an optimum filter; influence of the second detector upon the signal-to-clutter and signal-to-noise ratio.

The Phase Transition in Superconductors. II—Phase Propagation Above the Critical Field. T. E. Faber. *Proc. Royal Soc. (London), Ser. A*, Aug. 11, 1953, p. 75. 16 refs. Confirmation of the Pippard and Lifshitz theory for the control of propagation by an electromagnetic damping associated with the setting up of eddy currents.

Antennas

Aerial Radiation Patterns; Apparatus for Cathode-Ray Tube Display. T. T. Ling. *Wireless Engr.*, Aug., 1953, p. 192.

Effective Polarization on Elevated Aerial Direction Finders. D. W. G. Byatt. *Marconi Rev.*, 3rd Quarter, 1953, p. 128. Experiments in the 100–156 mc. per sec. frequency range.

The Four-Loop Antenna. Sterling R. Anderson, Hugh F. Keary, and William L. Wright. *U.S., CAA TDR 210*, June, 1953. 13 pp. Development and operational tests, with a description of the array and measurements covering horizontal plane patterns, impedance matching requirements, and polarization and bearing errors.

Circuits & Components

Audio-Frequency Filters Using Negative Feedback. T. Janisz. *Electronics*, Sept., 1953, p. 222.

Design Procedure for Crystal Lattice Filters. W. C. Vergara. *Tele-Tech.*, Sept., 1953, p. 86.

Electrokinetic Transducers. E. V. Hardway, Jr. *Instruments*, Aug., 1953, p. 1186. Discussion of properties and applications, including sensitivity, impedance, frequency response, pressure range, linearity, noise, and temperature range.

Electronic Counter. Erwin Levey. *Radio & TV News*, Sept., 1953, p. 43. Details of a simplified unit applicable to computers, timers, automatic control systems, and other counting and sorting devices.

Improving the F.M. Feeder Unit; Modifications Giving Better Oscillator Stability and Simpler Adjustment of Discriminator. S. W. Amos and G. G. Johnstone. *Wireless World*, Sept., 1953, p. 428. Includes circuit details and components.

Natural Frequencies of Coils and Windings. P. A. Abetti and F. J. Maginniss. *Elec. Eng.*, Sept., 1953, p. 781. Abridged.

New H.F. Proximity-Effect Formula. A. C. Sim. *Wireless Engr.*, Aug., 1953, p. 204.

New Nonrigid Materials for the Functional Design of Electrical Insulating Systems. Alex E. Javitz. *Elec. Mfg.*, Sept., 1953, p. 123. 23 refs. Evaluative

RESEARCH
ENGINEERING
DEVELOPMENT
DESIGN
PRODUCTION
OPERATION
TESTING
TRAINING
MAINTENANCE
FIELD SERVICE
Flight into fact
Bumping into a problem involving electronics...telemetrics...physics applications...aerodynamics? Land-Air services (listed above) and Land-Air Engineering, can frequently solve the problem more quickly and economically than you can do it yourself. If it's facts you need, call on Land-Air.
LAND-AIR, INC.
General Offices:
440 WEST SUPERIOR ST., CHICAGO 10, ILL.

survey of properties and applications of polyester, nylon, and fluorocarbon films, PVC tapes, mica and glass-fiber papers, composites, and other dielectric materials.

The Octantal Error in a Phase to Amplitude Conversion Circuit. D. H. Shinn and D. W. Watson. *Marconi Rev.*, 3rd Quarter, 1953, p. 121. Analysis of the error as found in the use of the Marconi VHF Direction Finder Type A.D. 200.

A Range of 400c/s and 1600c/s Transductors for Service Use. A. G. Milnes and C. S. Hudson. *Electronic Eng.*, Aug., 1953, p. 322. Application to magnetic amplifiers in servo-regulating systems.

G Curves & Impedance Amplifiers. Keats A. Pullen. *Tele-Tech.*, Sept., 1953, p. 71. Application of a new circuit technique; analysis of variations in transformer-coupled systems.

An Analysis of Magnetic Shift Register Operation. Eugene A. Sands. *Proc. IRE*, Aug., 1953, p. 993.

Magnetic Amplifier Circuits and Applications. R. A. Ramey. *Elec. Eng.*, Sept., 1953, p. 791. Abridged.

Square-Loop Core Magnetic Amplifiers. H. F. Storm. *Elec. Eng.*, Sept., 1953, p. 777. Abridged.

The Study of a Magnetic Inverter for Amplification of Low-Input-Power D.C. Signals. E. H. Frost-Smith. (*IEE Measurements Sect. Paper 1423.*) *Proc. IEE, Part II*, Aug., 1953, p. 362; Discussion, p. 371.

The Design of Electromagnets. I. L. R. Blake. *Electronic Eng.*, Sept., 1953, p. 380. Fundamental principles and specifications; circuit arrangements; core materials; methods to estimate leakage flux with the use of analogs and of scale models.

Magnetic Recording. Marvin Camras. *Tele-Tech.*, Sept., 1953, p. 81. New developments; reliability, cost, and other factors.

The Synchronous Magnetic Recorder and Its Applications. I—Theory. II—Experimental. G. Suryan. *J. Indian Inst. Sci., Sect. A*, July, 1953, pp. 193, 205.

The Gyrator as a 3-Terminal Element. Jacob Shekel. *Proc. IRE*, Aug., 1953, p. 1014.

Simplified Solution of Phase-Shift Networks. R. D. Trigg. *Electronic Eng.*, Aug., 1953, p. 331.

The Utilization of Degenerate Modes in a Spherical Cavity. Malcolm R. Currie. *J. Appl. Phys.*, Aug., 1953, p. 998. Extension of a general expression for an intermode coupling technique; applications.

Amplitude Stability in Oscillating Systems. Norman R. Scott. *Proc. IRE*, Aug., 1953, p. 1031. Method based upon energy balance conditions to determine a criterion for stability of oscillation for the case of one degree of freedom.

Balanced Crystal-Diode Modulator. William F. Byers. *Radio & TV News, Radio Electronic Eng. Sect.*, Sept., 1953, p. 10. To modulate signal generator output in the frequency range of 60–2,500 mc.

Low-Distortion Transistor Audio Oscillator. Peter G. Sulzer. *Electronics*, Sept., 1953, p. 171. Details of oscillator using three PNP junction transistors and operating at frequencies of 20, 200, 2,000, and 20,000 cycles per sec.

Wide-Band Data Transmitter. D. J. Gray, V. P. Gurske, and W. E. Morrow. *Electronics*, Sept., 1953, p. 168. Analysis of a frequency-modulated oscillator using double plantastron circuit for a linear data-recording system to handle information in the 0–5 kc. range; modulation characteristics.

Wide-Band V.H.F. Panoramic Receiver; Zero Beat Method of Producing Indicating Pulses. J. B. Lovell Foot. *Wireless World*, Sept., 1953, p. 392.

Complementary Symmetry Transistor Circuits. Robert D. Lohman. *Electronics*, Sept., 1953, p. 140. Basic principles; development of combinations of NPN and PNP junction transistors, with circuit details.

Junction Transistor Circuits. Engineering Dept. Staff. *Aerovox Res. Worker*, Apr.-May, 1953. 5 pp. Features and operating data for the CK 722.

Nonlinear Semiconductor Resistors. F. A. Schwertz and J. J. Mazenko. *J. Appl. Phys.*, Aug., 1953, p. 1015. Phenomenological theory of validity of the equation

$$i = kA^{p/m} d^{n-2} V^{n/t^n}$$

supported by measurements made on granular aggregates of silicon carbide.

A Note on the Analysis of Vacuum Tube and Transistor Circuits. L. A. Zadeh. *Proc. IRE*, Aug., 1953, p. 989. A simple method based on the use of tables of admittance (or impedance) coefficients to set up the node (or mesh) equations.

Obtaining Transistor Characteristics Curves. Warren Philbrook. *Radio & TV News*, Sept., 1953, p. 66. Rapid method to determine performance data on junction and point-contact transistors.

Selenium Diode Applications. J. T. Cataldo. *Radio & TV News*, Sept., 1953, p. 64. Potentialities for computer circuits, telemetering equipment, and other uses.

The Theory of Electronic Conduction in Polar Semi-Conductors. D. J. Howarth and E. H. Sondheimer. *Proc. Royal Soc. (London), Ser. A*, Aug. 11, 1953, p. 53. 13 refs. Solution of the Boltzmann equation by means of a variational method, with exact expressions for the electrical conductivity and the thermoelectric power obtained in the form of ratios of infinite determinants.

Transistor Characteristics. F. M. Dukat. *Radio & TV News, Radio Electronic Eng. Sect.*, Sept., 1953, p. 7. Production variations in the small signal and d.c. parameters of type PNP junction transistors.

Transistor Circuits and Applications. G. C. Sziklai. *Electronic Eng.*, Sept., 1953, p. 358.

Transistors. VIII—Use of Duality in Transistor Circuit Design. Thomas Roddam. *Wireless World*, Sept., 1953, p. 435.

Transistors: Theory and Applications. VII—Equivalent Transistor Circuits and Equations. Abraham Coblenz and Harry L. Owens. *Electronics*, Sept., 1953, p. 156.

Unipolar "Field-Effect" Transistor. G. C. Dacey and I. M. Ross. *Proc. IRE*, Aug., 1953, p. 970. Design nomographs and experimental verification of characteristics of units structurally similar to the ideal model of the theory.

Communications

Bits, Language Efficiency, and Information Theory. R. L. Shuey. *G-E Rev.*, Sept., 1953, p. 15. Transmission of information; coding and other problems.

Large Reductions of VHF Transmission Loss and Fading by the Presence of a Mountain Obstacle in Beyond-Line-of-Sight Paths. F. H. Dickson, J. J. Egli, J. W. Herbstreit, and G. S. Wickizer. *Proc. IRE*, Aug., 1953, p. 967.

On the Interference of Pulse Trains. K. S. Miller and R. J. Schwarz. *J. Appl. Phys.*, Aug., 1953, p. 1032. Analysis of time coincidence problems.

Some Aspects of the Spectrum of Modulated Pulses. V. Narayana Rao. *J. Indian Inst. Sci., Sect. B*, July, 1953, p. 125.

Construction Techniques

Automatic Production Machine for Close-Tolerance Printed Resistors. Jack Bayha. *Tele-Tech.*, Sept., 1953, p. 78. Design of the "Autobrader" applied to the printed circuit technique.

A Flexible Plated Circuit. E. R. Bowerman and R. F. Walton. *Radio & TV News, Radio-Electronic Eng. Sect.*, Sept., 1953, p. 12. New technique for fabrication of electronic equipment.

Metal-Clad Laminates Used in Printed Circuitry. Norman A. Skow. *Mech. Eng.*, Sept., 1953, p. 709.

Printed Circuits. Norman Skow. *SPE J.*, Sept., 1953, p. 9. Properties, fabrication and assembly requirements, and applications.

Solderless Electronic Assembly with Cellular Units. P. J. Selgin. *Elec. Mfg.*, Sept., 1953, p. 139.

Electronic Controls

Automatic Control System With Provision for Scanning and Memory. N. H. Young. *Elec. Eng.*, Sept., 1953, p. 782. Analysis of a system with an adjustment control element to produce a maximum or minimum value of a resulting parameter.

Control in Industry. A. W. Schmitz and H. L. Palmer. *G-E Rev.*, Sept., 1953, p. 48. Basic principles of amplifiers, analog computers, and other controls; applications, with comparative data.

Methodik der Berechnung von Regulierungen; Servotechnik. Heinrich E. Weber. *ZAMP*, July 15, 1953, p. 233. In German. Essential characteristics of the linear phase-attenuation method for the design of feedback-control regulators to increase stability and series and parallel compensation; analysis of the influence of disturbances, transient behavior, and the effect of finite delay within any system.

Reduction of Forced Error in Closed-Loop Systems. Leonard H. King. *Proc. IRE*, Aug., 1953, p. 1037. Application to servomechanisms and control design.

Stagger-Tuned Loop Antennas for Wide-Band Low-Frequency Reception. David K. Cheng and Ralph A. Galbraith. *Proc. IRE*, Aug., 1953, p. 1024. USAF-sponsored research at Syracuse University.

A Study of a Second Order Sampling Servo. S. R. Cooper. *Electronic Eng.*, Aug., 1953, p. 342. Fundamental principles and behavior patterns of an electronic control system.

The Flexbelt Valve may be used with an electronic control circuit. A two-stage servo-type motor drives the valve through a gear reduction including an overload clutch. An integral position potentiometer geared to drum provides an electrical indication of valve position for speed feedback control.
FLEXBELT VALVES
FOR FAST REMOTE CONTROL OF FUEL, WATER, OIL, OR AIR

The Flexbelt Valve is designed for fast remote control of flow media on high-speed aircraft. It handles large flows and controls high pressures over a wide range with low power requirements.

Pressure of the flow medium holds the Flexbelt Valve member (Teflon-impregnated glass fabric) tightly against the orifice openings, thus cutting off flow completely when the valve is closed. Flow is controlled by rolling the Flexbelt onto a concentric motorized drum, thus peeling the belt away from the inside surface of a cylindrical seat. The valve seat, Flexbelt, and valve shaft form a sub-assembly permitting change in the valve flow characteristic by replacement as a unit.

Specific applications of the Flexbelt Valve include remote fuel flow control in aircraft fuel systems and control of maximum exhaust gas temperature by variation of fuel flow to a turbojet engine.

We believe our long experience, extensive facilities for developing, manufacturing and testing control system components for high-speed aircraft can be helpful to you. Our engineering counsel is at your service. We welcome your inquiry.

SPECIFICATIONS —
Flexbelt Valve Type 141VR

FLOW MEDIA: Water, gasoline, kerosene, oil, air, and gas. **FLOW MEDIUM TEMPERATURE:** Minus 65°F. to plus 250°F. **FLOW RANGES:** Up to 25 gpm of water at 25 psi pressure drop. **FLOW CHARACTERISTICS:** Linear, non-linear, logarithmic. **OPERATING PRESSURE:** Up to 1200 psi maximum. **OPERATING SPEED:** 3 seconds from full open to full close. **VOLTAGE:** 110 v. 60 cycles or 50 v. 400 cycles. **POWER:** 12 watts maximum. **POTENTIOMETER:** From 0–10,000 ohms in several sizes. **CONNECTORS:** AN3102-16S-5P for motor. AN3102-10SL-3P for potentiometer. **MATERIALS:** Housing — light weight aluminum; explosion-proof. Valve — aluminum and stainless steel. Flexbelt — Teflon-impregnated glass fabric; unaffected by aromatics in aircraft gasoline. Bearings — self-lubricating powdered metal. **WEIGHT:** 5 lbs. **SIZE:** 3" x 4½" x 4".

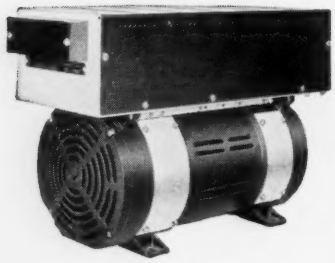
MANNING, MAXWELL & MOORE, INC.

AIRCRAFT PRODUCTS DIVISION • STRATFORD, CONN.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

OUR AIRCRAFT PRODUCTS INCLUDE: TURBOJET ENGINE TEMPERATURE CONTROL AMPLIFIERS • ELECTRONIC AMPLIFIERS PRESSURE SWITCHES FOR ROCKETS, JET ENGINE AND AIRFRAME APPLICATIONS • PRESSURE GAUGES THERMOCOUPLES • HYDRAULIC VALVES • JET ENGINE AFTERBURNER CONTROL SYSTEMS

The most complete line of AIRCRAFT INVERTERS



The Red Bank Division of Bendix Aviation Corporation is the logical place to find your answer to aircraft inverter needs—and for three significant reasons. First, we offer the widest range of inverters. Second, we design and build each inverter as a complete, unified mechanism. Third, we are equipped to design and produce inverters for all kinds of special-purpose applications . . . and, in fact, are now engaged in developing inverters up to 5000 VA and for high temperature, high altitude applications. Our current production models are described below. For complete details on these and also on special-purpose designs, write Aircraft Inverter Section, Bendix Red Bank Division, Eatontown, N. J.

INVERTERS—400 CYCLE OUTPUT

Type Number	INPUT		OUTPUT			Approx. Weight Lbs.	Max. Alt. Feet	Designed to Govt. Part No.
	Volts	Amps	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	5	35000	AN3496-1 AF
MG-54	27.5	22	115/200	1	250	18	65000	E-51A1A-9 Navy
				3	250			
12142	27.5	22	115	1	250	13	35000	N17I58 Navy
				3	250			
12146	27.5	22	115	1	250	13	35000	53B6239 AF
MG-60	27.5	22	115	1	250	17	65000	53B6239 AF
MG-62	27.5	22	115	3	250	17	65000	AN3532-2
32E01	27.5	35	115	1	500	26	50000	AN3533-1
				3	500			
32E00	27.5	45-54	115	1	500	34	50000	AN3534-1
				3	750			
MG-44	27.5	55	115/200	1	750	35	50000	E-52804-2 Navy
				3	750			
MG-57	27.5	100	115/200	1	1250	42	50000	E1737-1 Navy
				3	1500			
MG-61	27.5	100	115	1	1500	51	65000	—
MG-64	27.5	100	115	3	1500	51	65000	—
1518 Mod. 1 & 2	27.5	130	115	1	1500	37.5	20000	—
				3	1800			
1518 Mod. 5	27.5	130	115	1	1500	37.5	35000	—
				3	1800			
32E06	27.5	180	115/200	1	2250	56	50000	E1725-1 Navy
				3	2500			
32E03	27.5	180	115	1	2500	56	50000	AN3516-1
32E09	27.5	180	115	1	2500	56	50000	—
				3	3000			

NOTE: D.C. Input voltage shown is a nominal value of 27.5 volts, but all units are designed to operate from 26 to 29 volts. Input Amperes shown are values at 27.5 volt input.

Manufacturers of Special-Purpose Electron Tubes, Inverters, Dynamotors and Fractional HP D. C. Motors

Bendix DIVISION OF Red Bank

EATONTOWN, N. J.

THE NAME Bendix AVIATION CORPORATION MILLIONS TRUST

West Coast Sales and Service: 117 Providencia Ave., Burbank, Calif.

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

Electronic Tubes

Applying Pulse Magnetrons to Radar Equipment. I. Charles V. Litton and Paul W. Crapuchettes. *Tele-Tech.*, Sept., 1953, p. 60. Analysis of design errors underlying current reliability problems of absolute ratings; physical and mechanical environmental aspects.

Beam Switching Tubes for Computers and Controls. Saul Kuchinsky. *Tele-Tech.*, Sept., 1953, p. 88. Characteristics and functions; reliability factors.

Cathode-Follower Design Charts. N. O. Sokal. *Electronics*, Sept., 1953, p. 192. A simplified graphic procedure to calculate output impedance versus input voltage for nine tube types, with resistor values for specific operating points.

Control of Thyratrons by Small Signals. R. Bailey. *Electronic Eng.*, Sept., 1953, p. 374. General principles and circuit design.

Debunching of Electron Beams Constrained by Strong Magnetic Fields. M. Chodorow, E. L. Ginzton, and E. J. Nalos. *Proc. IRE*, Aug., 1953, p. 999. Experimental study to check Feenberg's small-signal theory.

Diffusion of Barium in an Oxide-Coated Cathode. Renate S. Bever. *J. Appl. Phys.*, Aug., 1953, p. 1008. 15 refs.

A Method for Improving the Read-Around-Ratio in Cathode-Ray Storage Tubes. Josef Kates. *Proc. IRE*, Aug., 1953, p. 1017. A "barrier grid" function for the C-R tube; application to digital computers.

Squirrel-Cage Filament Structures; Equivalent Cathode Diameter. A. M. Hardie. *Wireless Engr.*, Aug., 1953, p. 196. 17 refs.

The Theory and Design of Cathode Follower Output Stages. E. T. Emms. *Electronic Eng.*, Sept., 1953, p. 386. Circuit analysis and procedures for choice of tubes for various applications; design limitations.

Measurements & Testing

Accurate R.F. Power Measurements. R. M. Soria and J. G. Krisilas. *Radio & TV News, Radio Electronic Eng. Sect.*, Sept., 1953, p. 3. Calorimetric method to determine radio-frequency output in the 2–5,000-watt range and to calibrate an input power indicator.

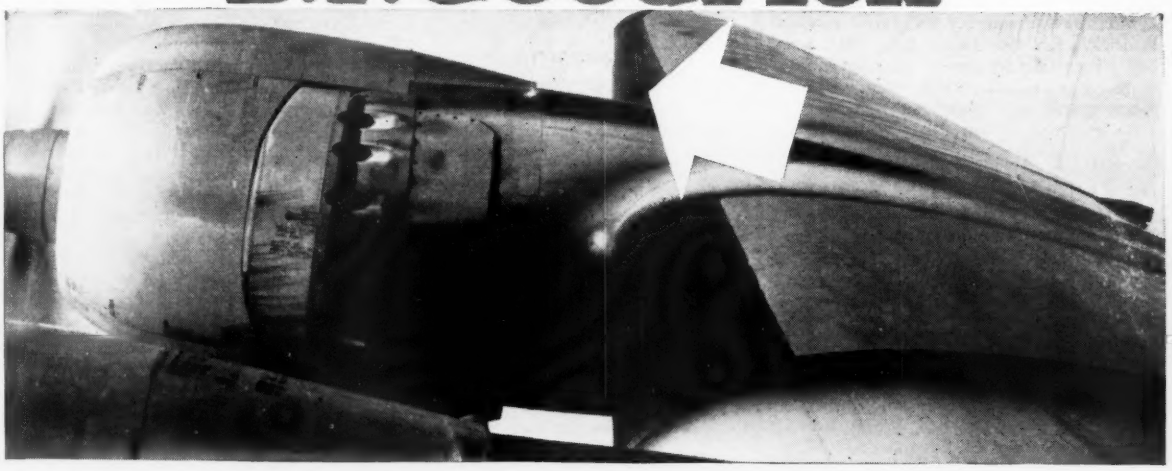
Balance Measurements on Balun Transformers. O. M. Woodward, Jr. *Electronics*, Sept., 1953, p. 188. Theoretical and experimental analysis of relative balance quality and optimum operating conditions; description of a comparator to measure balance efficiency; results of tests on typical UHF and VHF balance-to-unbalance isolation transformers.

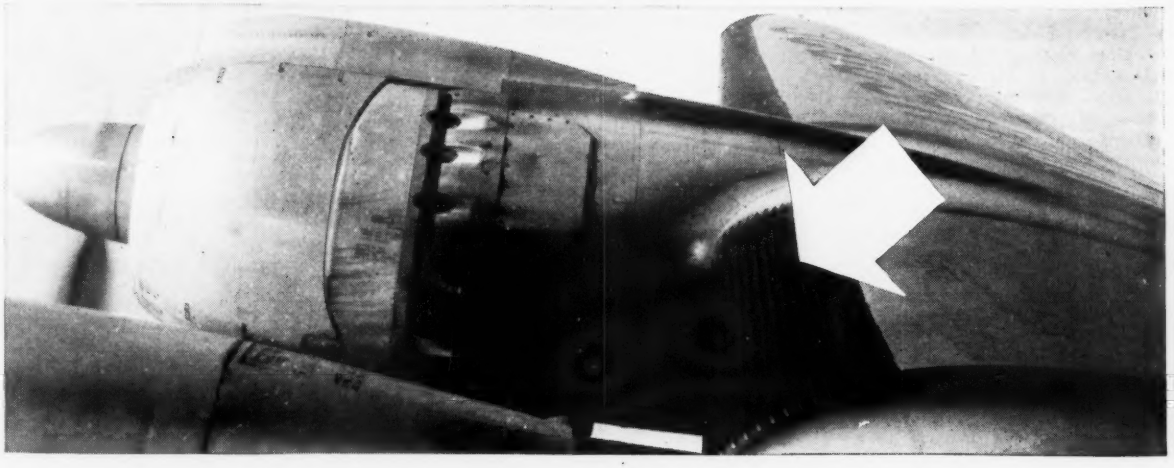
A Direct-Reading Microdensitometer. R. I. Tait and F. C. Chalklin. *J. Sci. Instr.*, Aug., 1953, p. 268. Circuit principles; testing and performance of the apparatus that uses a logarithmic triode amplifier.

Measurement of the Small Signal Parameters of Transistors. Geoffrey Knight, Jr., Richard A. Johnson, and Roland B. Holt. *Proc. IRE*, Au_., 1953, p. 983.

Methods of Measuring the Properties of Ionized Gases at High Frequencies. IV—A Null Method of Measuring the

B.F.Goodrich





How new B.F.Goodrich De-Icer removes ice faster, better

THOSE LITTLE "RIBS" seen on the wings are rubber tubes that were inflated *very quickly* to crack off ice, so it can be blown away in the airstream. See how the inboard wings are inflated, outboard deflated in the bottom picture. The cycle is just reversed in the other picture. Earliest B. F. Goodrich De-Icers had only three to five tubes, yet provided year-round safety to the airlines as early as 1930.

This latest B. F. Goodrich De-Icer has a lot of *new* advantages. For example, the ¾-inch tubes inflate *faster* with almost three times the air pressure of earlier types. This quicker action breaks off ice faster, cleaner. The "rest period" of the inflating cycle is longer. This cuts down disturbance of the airflow so much it isn't even a factor.

And the De-Icers last longer. The reason: new types are tailored to exact shape and size, then simply cemented on the airplane. No stretching under tension, no mechanical attachments. Of course they're lighter, take up little space for plumbing, are easy to take care of.

These new De-Icers are on all the new Super Constellations. They represent just another development of BFG research for the aviation industry.

Send this coupon if you would like more information about any BFG aeronautical products. Check the items; print your name and address in the margin below (or pin to your company letterhead).

☐ Tires
☐ Wheels and Brakes
☐ De-Icers
☐ Heated Rubber
☐ Avtrim
☐ Plastilock Adhesives
☐ Pressure Sealing Zippers
☐ Canopy Seals
☐ Fuel Cells
☐ Rivnuts
☐ Hose and other accessories
☐ Please have representative call

Mail to The B. F. Goodrich Co. Dept. A-90, Akron, Ohio

Discharge Admittance. Lawrence Gould and Sanborn C. Brown. *J. Appl. Phys.*, Aug., 1953, p. 1053. Theoretical and experimental investigations at MIT.

Microwave Frequency Standard. L. C. Hedrick. *Rev. Sci. Instr.*, Aug., 1953, p. 565. For UHF frequency measurements designed as an accessory of a microwave spectrograph.

A Sensitive Differential Wattmeter. L. M. Clarebrough, M. E. Hargreaves, D. Michell, and G. W. West. *J. Sci. Instr.*, Aug., 1953, p. 282. For the direct measurement of small differences between electrical power supplied to two circuits; application to the analysis of energy stored in metals during cold deformation.

Simple Distortion Meter; Provision for Qualitative Inspection of Distortion Products. V. J. Tyler. *Wireless World*, Sept., 1953, p. 431. Analysis of circuit behavior and of the empirical equalizer design for the solution of the amplifier problem.

A Square-Wave Shaper. George Ellis Jones, Jr. *Radio & TV News*, Sept., 1953, p. 63. Design, construction, and operation of an audio test unit usable in conjunction with a sine-wave generator.

Transfer Function Measuring and Recording System. R. J. Ehret, E. F. Hochschild, J. M. Embree, and E. C. Grogan. *Elec. Eng.*, Sept., 1953, p. 796. Abridged. Principles of operation; applications to process controllers and instrument servomechanisms.

Transmission Lines

Applications of Microwaves in Scientific Research. Hans Herbert Klinger. *J. Franklin Inst.*, Aug., 1953, p. 129. 24 refs. Review of developments; experimental techniques; wave-guide and other principles.

Determination of Reflection Coefficients and Insertion Loss of a Wave-Guide Junction. Georges A. Deschamps. *J. Appl. Phys.*, Aug., 1953, p. 1046. Analysis by the scattering matrix method.

A Simple Graphical Analysis of a Two-Port Waveguide Junction. J. E. Storer, L. S. Sheingold, and S. Stein. *Proc. IRE*, Aug., 1953, p. 1004. A direct computation based on the scattering matrix method of Deschamps.

Wave Propagation

The Constants in the Equation for Atmospheric Refractive Index at Radio Frequencies. Ernest K. Smith, Jr., and Stanley Weintraub. *Proc. IRE*, Aug., 1953, p. 1035. Study of recent experiments giving the relation:

$$N = (77.6/T)\,[p + 4{,}810\,(e/T)]$$

for the radio propagation problem.

Ground Wave Propagation Curves for Frequencies from 150 Kc/s. to 10 Mc/s. G. Millington and J. C. Thackray. *Marconi Rev.*, 3rd Quarter, 1953, p. 109. 15 refs.

Propagation of Microwaves Through a Cylindrical Metallic Guide Filled Coaxially with Two Different Dielectrics. II. S. K. Chatterjee. *J. Indian Inst. Sci., Sect. B*, July, 1953, p. 103.

A Study of Individual Radio Atmospherics Received Simultaneously at Two Places. P. W. A. Bowe. *Philos. Mag. (7th Ser.)*, Aug., 1953, p. 833. Further observations and experimental analysis of radio wave propagation of 2 to 16 kc. per sec. frequencies, with a 1,000 km. propagation factor.

Equipment

Electric

Balancing and Vibration Problems Related to Rotating Electrical Machinery. O. Leroy Purtee. *GM Eng. J.*, June-July, 1953, p. 16. Analytical procedures and measuring devices to determine maximum vibration in rotor unbalance.

Use of Field Test Data for Control System Analysis. P. R. Hoyt and B. D. Stanton. *Instruments*, Aug., 1953, p. 1180. Study of electrical test equipment, methods of producing step-input and frequency-type disturbances, and other practical factors.

Hydraulic & Pneumatic

Contributions to Hydraulic Control. III—Pressure-Flow Relationships for 4-Way Valves. IV—Notes on the Hydraulic Wheatstone Bridge. V—Lateral Forces on Hydraulic Pistons. J. F. Blackburn. *Trans. ASME*, Aug., 1953, pp. 1163; 1171; 1175.

Filter Efficiency and Standardization of Test Dust. H. Heywood. *IME Proc. (B)*, No. 5, 1952, p. 169; Discussion, p. 175; Communications, p. 180. Theoretical analysis of the efficiency of air cleaners such as the ones used to control air-borne dust in aircraft engines.

Hydraulic Control Systems. V—Servo Systems. R. Hadekel. *Mach. Des.*, Aug., 1953, p. 165. Design of a servomechanism and of a regulator to aid development of circuits for maximum simplicity and effectiveness.

JIC Hydraulic Diagrams. *Tool Engr.*, Sept., 1953, p. 79. Standard definitions, terminology, and symbols adopted at the Joint Industry Conferences, Jan., 1953.

Mechanical Lock and Signal Devices for Aircraft Hydraulic Cylinders. Alfred B. Sammis and Michael Tarasewich. *Appl. Hydraulics*, Sept., 1953, p. 82. Principles of ball-lock design; applications.

New Power for Ancillaries. *The Aeroplane*, Aug. 14, 1953, p. 202, cutaway drawing. Analysis of the Rotax-Godfrey turbo-alternator for compressed-air equipment.

Procedure for Selection of Fluid Drive Units. A. E. Kremiller. *Appl. Hydraulics*, Sept., 1953, p. 52. For Convair and Bendix hydraulic centrifuge drives for operational testing of guided missiles and other equipment.

Pros and Cons of Hydraulically Actuated Clutches. E. B. Falk. *Mach. Des.*, Aug., 1953, p. 183.

Triple Torture Test Applied with Oil Power. J. P. Moorhead. *Appl. Hydraulics*, Sept., 1953, p. 65. Design and construction of a hydraulic machine to test aircraft seats.

Flight Operating Problems

Aircraft Approach Tolerances. Arthur E. Jenks. *Air Line Pilot*, Sept., 1953, p. 10. Limitations of piloting technique and Navigation equipment.

An Analysis of the Power-Off Landing Maneuver in Terms of the Capabilities of the Pilot and the Aerodynamic Characteristics of the Airplane. Albert E. von Doenhoff and George W. Jones, Jr. *U.S., NACA TN 2967*, Aug., 1953. 42 pp.

Insonorisation d'un Biréacteur Expérimental de Transport des Passagers. Michel Kobrynski. *La Recherche Aéronautique*, May-June, 1953, p. 8. In French. Anti-noise study of an experimental dual-jet passenger transport.

Investigation of Aerodynamic and Icing Characteristics of a Flush Alternate-Inlet Induction-System. James P. Lewis. *U.S., NACA RM E53E07*, July 24, 1953. 42 pp.

A Method for Calculating the Evaporation from Water Sprays in an Icing Tunnel. E. L. Smith and O. R. Ballard. *Canada, NAE LR 60*, May 22, 1953. 22 pp.

Flight Safety & Rescue

Accelerations and Passenger Harness Loads Measured in Full-Scale Light-Airplane Crashes. A. Martin Eiband, Scott H. Simpkinson, and Dugald O. Black. *U.S., NACA TN 2991*, Aug., 1953. 67 pp.

Appraisal of Hazards to Human Survival in Airplane Crash Fires. Gerard J. Pesman. *U.S., NACA TN 2993*, Sept., 1953. 98 pp. 16 refs.

Complicated Safety. William I. Stieglitz. *Flying Safety (USAF)*, Aug., 1953, p. 9. Design simplification factors.

Fuels & Lubricants

Effective Storage Temperatures of Gasoline; Desert-Storage Tests on Motor and Aviation Gasoline. Daniel B. Luten, Jr., and Kenneth Hedberg. *Ind. & Eng. Chem.*, Sept., 1953, p. 2098. 20 refs. Climatologic investigations.

Flame-Stability Studies with Mixed Fuels; Hydrocarbons, Hydrogen, and Hydrogen Sulfide. Philip F. Kurz. *Ind. & Eng. Chem.*, Sept., 1953, p. 2072.

Vapor-Liquid Equilibrium Relations. Mitsuho Hirata. *Japan Sci. Rev.*, Apr., 1952, p. 265. 50 refs. Experimental study of a binary system.

Lubricants & Lubrication

Contact and Rubbing of Flat Surfaces. J. F. Archard. *J. Appl. Phys.*, Aug., 1953, p. 981. Experimental analysis of wear and friction of various solids.

Contribution to the Theory of Oil Whip. H. Poritsky. *Trans. ASME*, Aug., 1953, p. 1153; Discussion, p. 1158. 13 refs.

The Lubrication of Gyroscopes. J. E. Brophy and J. B. Romans. *Trans. ASME*, Aug., 1953, p. 1147. Analysis of measurements of bearing temperatures, rotor speed, rate of deceleration, power input, bearing noise level, and other factors in terms of maintenance and lubrication requirements.

On the Solution of the Reynolds Equation for Slider-Bearing Lubrication. IV—Effect of Temperature on the Viscosity. V—The Sector Thrust Bearing. A. Charnes, E. Saibel, and A. S. C. Ying. **VI—The Parallel-Surface Slider Bearing**

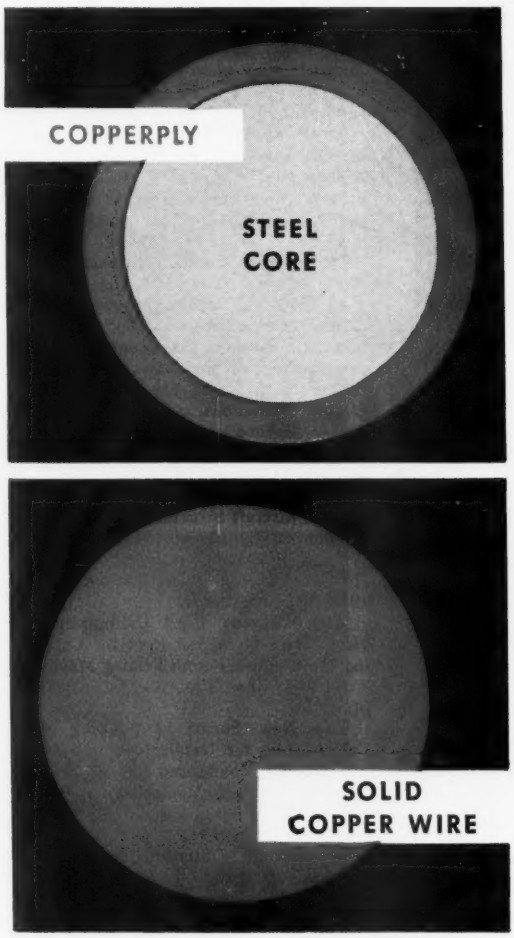
cost-cutting

stronger

more dependable

Now available..COPPERPLY

A NEW COPPER-PLATED STEEL WIRE
OF UNMATCHED NATIONAL-STANDARD QUALITY



COPPERPLY, accurately concentric and uniform, is steel wire electroplated with copper to the thickness required. This type wire was originally used for television lead-in installations. Now this unique wire is solving cost problems in many new applications.

Maybe COPPERPLY gives you ideas for applications in your field . . . uses that will result in substantial savings over solid copper wire.

In addition to cutting costs, COPPERPLY obviously is much stronger than copper wire. And National-Standard makes it with a regular or high tensile steel wire core to fill your specific requirements.

We'll "loan" you an engineer to help you develop any ideas for using COPPERPLY you'd like to explore. It's company policy to give the best service in the industry, in addition to the highest quality special wire and steel products available. Write the National-Standard Company, Niles, Michigan, concerning COPPERPLY. Write the appropriate division listed below on other products.

DIVISIONS OF
NATIONAL-STANDARD

NATIONAL-STANDARD Company
NILES MICHIGAN

NILES, MICHIGAN

Athenia Steel, Clifton, N. J.
Flat, High Carbon, Cold Rolled Spring Steel

National-Standard, Niles, Mich.
Tire Wire, Stainless, Fabricated Braids and Tape

Reynolds Wire, Dixon, Illinois
Industrial Wire Cloth

Wagner Litho Machinery, Jersey City, N.J.
Metal Decorating Equipment

Worcester Wire Works, Worcester, Mass.
Round and Shaped Steel Wire, Small Sizes

SEEING IS BELIEVING

Supplying the right answers to pilots and navigators by means of accurate, reliable instruments has been our work for more than twenty-four years.

- AIRCRAFT INSTRUMENTS AND CONTROLS
- OPTICAL PARTS AND DEVICES
- MINIATURE AC MOTORS
- RADIO COMMUNICATIONS AND NAVIGATION EQUIPMENT

Current production is largely destined for our defense forces; but our research facilities, our skills and talents, are available to scientists seeking solutions to instrumentation and control problems.

kollsman INSTRUMENT CORP.

ELMHURST, NEW YORK • GLENDALE, CALIFORNIA • SUBSIDIARY OF Standard COIL PRODUCTS CO., INC.

Without Side Leakage. F. Osterle, A. Charnes, and E. Saibel. *Trans. ASME*, Aug., 1953, pp. 1117, 1125, 1133. 26 refs.

Gliders

The "INAV-1." Reimar Horten. *Sailplane & Glider*, Aug., 1953, p. 10. Design, description, and performance data.

Instruments

Automatic Control of a Pressure Process. N. H. Ceaglske and D. P. Eckman. *Ind. & Eng. Chem.*, Sept., 1953, p. 1879. Analytic and experimental investigation of the dynamic characteristics of a simple gas pressure process involving thermodynamics and fluid flow; applications.

An Inexpensive Recording Differential Manometer Suitable for Reaction Kinetics Measurements. George R. Thomas and Norman N. Lichtin. *Rev. Sci. Instr.*, Aug., 1953, p. 661. Apparatus to record reaction system pressure automatically as a function of time.

The Lubrication of Gyroscopes. J. E. Brophy and J. B. Romans. *Trans. ASME*, Aug., 1953, p. 1147. Analysis of measurements of bearing temperatures, rotor speed, rate of deceleration, power input, bearing noise level, and other factors in terms of maintenance and lubrication requirements.

The 1954 Instruments Index. *Instruments*, Aug., 1953, Part II. 212 pp. Alphabetical listings of products and manufacturers of measuring, computational, testing, and automatic control devices.

Interpolation Servomechanisms. J. T. Fleck. *Cornell Aero. Lab. Rep. UA-624-P-1*, 1953. 23 pp. Analyses of polynomial tracker, response to arc-tangent function, random noise on input, and extrapolation or prediction.

Servomechanisms for Industry. I—Simple Definitions of Terms, Types of Servos, Basic Elements and Performance Criteria. F. B. MacLaren. *Appl. Hydraulics*, Sept., 1953, p. 58.

Calibration of Strain-Gage Installations in Aircraft Structures for the Measurement of Flight Loads. T. H. Skopinski, William S. Aiken, Jr., and Wilber B. Huston. *U.S., NACA TN 2993*, Aug., 1953. 70 pp. 12 refs.

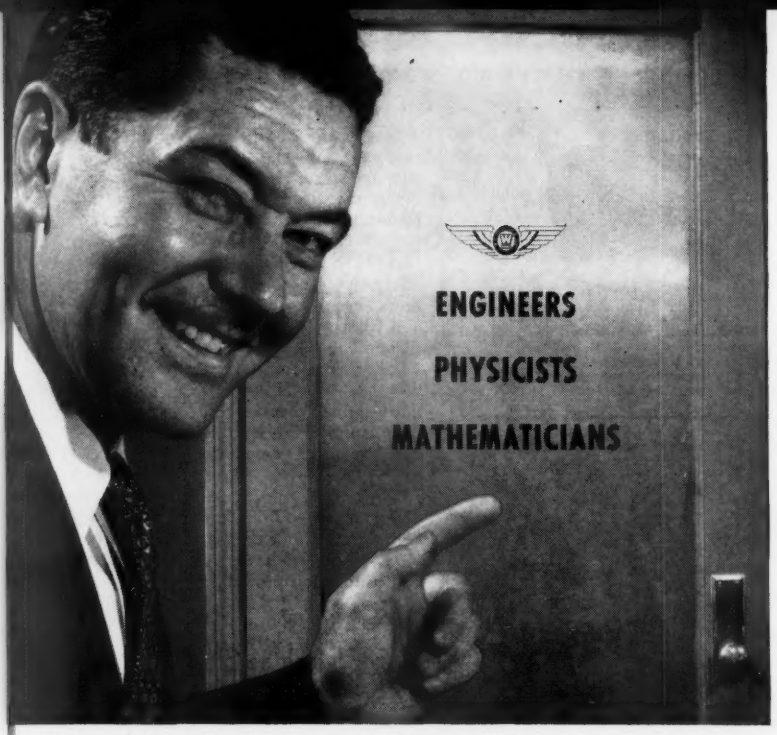
High Capacity Load Calibrating Devices; NBS Dynamometers for Calibrating Multimillion Pound Testing Machines. *U.S., NBS Sum. TR 1801*, July, 1953. 6 pp.

Two New Forms of Melting Point Calorimeters for Determining the Purity of Liquids of Condensed Gases. John T. Clarke, Herrick L. Johnston, and Warren De Sorbo. *Anal. Chem.*, Aug., 1953, p. 1156.

Wide-Range Calibrator for Vibration Pickups. Wilfred A. Yates and Martin Davidson. *Electronics*, Sept., 1953, p. 183. Nonloading displacement transducer used with vibration generator to measure vibration pickups in 0.01-inch to 10-microin. range.

Flow-Measuring Devices

Mass Spectrometer for Automatic Process Control. James R. Bradburn. *Elec.*

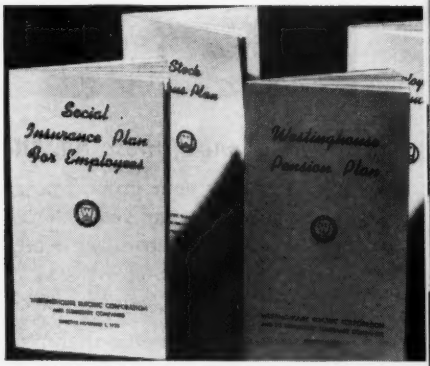


Look at these new opportunities in jet engineering at Westinghouse

1. Immediate openings in research, development and manufacturing at our Aviation Gas Turbine Division in Philadelphia or Kansas City, Mo. Salaries are good, varying with experience and ability. You'll enjoy working with us.

2. Challenging work offers the opportunity of joining with Westinghouse, a long-time leader in jet engineering.

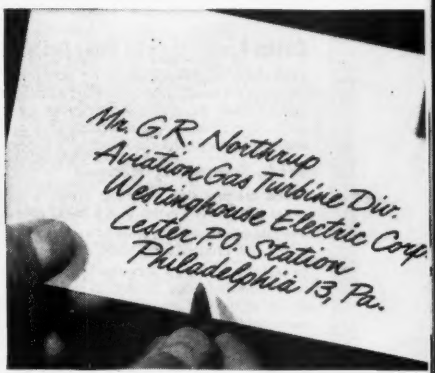
3. Incentive awards are given for inventions and ideas. Creative work is recognized and rewarded. We even pay your tuition for graduate study.



4. "Extras" include a modern pension plan; low-cost life, health, and accident insurance; stock purchase plan.

5. Security we consider important. Promotion is from within. We're in this new, expanding industry to stay.

6. Living conditions in Philadelphia and Kansas City suburbs are good with easy access to recreational activities. We will help you find housing.

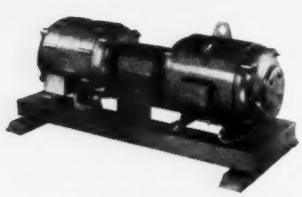


7. Write today to this address; send full details. We'll arrange for a confidential interview for all qualified applicants.

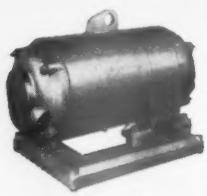
J-54023

YOU CAN BE **SURE**... IF IT'S

Westinghouse

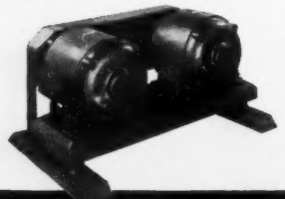


Stationary installation, direct connected drive, for inspection and test of high frequency components and completed assemblies.

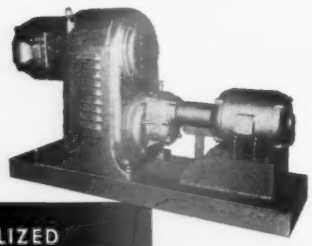


Stationary installation, 2-bearing common shaft motor-drive, for inspection and test of high frequency components and completed assemblies.

Stationary installation, vee belt drive, resilient mounted for laboratory h.f. test equipment.



Variable frequency installation for research test work.



FOR STANDARD AND SPECIALIZED

HIGH FREQUENCY

POWER REQUIREMENTS

Get one of these **AMERICAN ELECTRIC** *"Packaged" Units!*

Whatever your ground power supply requirements—standard or special—you can get the *exact unit* best suited to your needs from American Electric. These high frequency power supplies are built with many motor-drive variations. Units are complete with d.c. exciter-regulators, ready to connect to your 60 cycle mains.

Exclusive inductor-alternator design eliminates all springs, slip rings and brushes . . . *maintenance-free as its grease-sealed ball bearings!* Light in weight, compact, quiet!

Correct Power Supply for Every Installation

Portable, semi-portable or stationary types, open models or completely enclosed for weather protection. Caster or pneumatic tire mounts, skid mounts and resilient rubber mounts on stationary types.

Wide Frequency Ranges

Fixed Frequencies from 250 cycles to 2400 cycles (up to 4000 cycles in the lower ratings).

Variable Frequencies from 380 cycles to 1200 cycles and 1200 cycles to 2400 cycles.

Excellent Voltage Regulation: Standard ± 1% to as low as ± .5% depending upon choice of drive. Electronic regulators or magnetic amplifier regulators supplied.

Motor Drives—Common shaft, direct connected, Vee belt or positive, no-slip timing belt types. Variable speed on variable frequency models.

Low Harmonic Content
Less than 2% on single phase.
Less than 1% on three phase.
Exceedingly low harmonic content results directly from alternator design without use of filters.

Output Ranges
single phase—½ KVA to 15 KVA
three phase—½ KVA to 30 KVA
(outputs up to 75 KVA available in other alternator designs.)

WHATEVER YOUR GROUND POWER SUPPLY REQUIREMENTS

ASK American Electric for quotation

Engineering Representatives:
TRAVCO ENGINEERING CO.
Silver Spring (Md.) • Chicago
New York • Los Angeles

Manufacturers Also of Miniature A.C. (All Frequencies) Electric Drive Motors, Blowers and Fans

AMERICAN ELECTRIC MOTORS
TRADE MARK

4811 Telegraph Road, Los Angeles 22, California

Mfg., Sept., 1953, p. 112. Permits continuous analysis of gaseous flows, separating and measuring selected constituents.

On the Study of the Technical Viscometer. I, II. Sigezō Iwanami. *Japan Sci. Rev.*, Apr., 1952, p. 235. Construction of the apparatus with an experimental analysis of the characteristics of viscous flows through tubes and orifices.

A Simple Low-Frequency Double-Flash Stroboscope. J. E. Caffyn and R. M. Underwood. *J. Sci. Instr.*, Aug., 1953, p. 257. Apparatus, using two Siemens SF6 flash-discharge tubes controlled electronically, to measure fluid velocities.

A Vacuum Anemometer. D. J. Trevoy and W. A. Torpey. *Rev. Sci. Instr.*, Aug., 1953, p. 676. For measuring projective vapor emission from liquid surfaces into high vacuum and the flow of gas through pipes; description of apparatus; testing and calibration procedures.

Machine Elements

Cam Curvature. I—Reciprocating In-Line Flat-Faced Follower. A. R. Holowenko and A. S. Hall. *Mach. Des.*, Aug., 1953, p. 170. Graphic methods for finding velocities and accelerations of cam followers.

Experiments With Water-Lubricated Tapered-Land Thrust Bearings. Maurice Levinsohn and N. E. Reynolds. *Trans. ASME*, Aug., 1953, p. 1137.

Nomographic Method for Sleeve Bearing Design. D. F. Wilcock and M. Rosenblatt. *Mach. Des.*, Aug., 1953, p. 143, folded charts. A simplified procedure to pre-determine performance requirements.

On the Solution of the Reynolds Equation for Slider-Bearing Lubrication. IV—Effect of Temperature on the Viscosity. V—The Sector Thrust Bearing. A. Charnes, E. Saibel, and A. S. C. Ying. **VI—The Parallel-Surface Slider Bearing Without Side Leakage.** F. Osterle, A. Charnes, and E. Saibel. *Trans. ASME*, Aug., 1953, pp. 1117, 1125, 1133. 26 refs.

Materials

Corrosion & Protective Coatings

Contact Immersion-Plating; Depositing Protective-Coatings on Internal Surfaces and Parts of Difficult Shape. J. K. Wilson and O. Wright. *Aircraft Prod.*, Sept., 1953, p. 329.

Corrosion and Its Control. *Douglas Serv.*, July-Aug., 1953. 24 pp.

Corrosion Resistance of Galvanized-Steel-Stitched Aluminum Alloys. *U.S., NBS Sum. TR 1787*, Aug., 1953. 5 pp. NACA - NavBuAer - WADC - sponsored NBS investigation.

High Temperature Cr-Ni Alloy; Corrosion. Mars G. Fontana. *Ind. & Eng. Chem.*, Sept., 1953, p. 95A. For applications requiring temperatures up to 2,200°F.

Materials & Methods Manual No. 96: Selecting Protective Coatings for Metals. John B. Campbell. *Materials & Methods*, Aug., 1953, p. 109.

TAKE A CLOSE LOOK AT TEMCO'S

3 coordinated plants!

TEMCO IN DALLAS

Main plant and headquarters where major subcontract manufacturing operations as well as new aircraft design activities are concentrated. Over 1,000,000 square feet of floor space, including recently enlarged facilities to accommodate expanding engineering and design sections.

TEMCO IN GREENVILLE, TEXAS

Sixty miles northeast of Dallas is TEMCO's Overhaul Division . . . completely equipped for assembly-line modification and overhaul of multi-engine aircraft. TEMCO's comprehensive rehabilitation services are now offered to executive aircraft operators as well as the services and airlines.

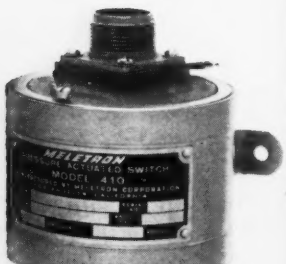
TEMCO IN GARLAND, TEXAS

Only a few minutes away from the main plant is one of the most complete aircraft sub-assembly fabrication facilities in the Southwest. Recently completed expansion program has almost doubled working areas.

TEMCO ®
AIRCRAFT CORPORATION
DALLAS, TEXAS

Every investor in the stock market buys with full knowledge that his securities may appreciate or decline.

we're eliminating chances of failure



*From zero absolute to 12,000 psi gauge.

Aircraft engineers and designers are seeking a similar goal. Unitedly, they agree: *We must eliminate the chances of a failure.* In this quest to prevent the *chance* of failure in systems, Meletron has perfected pressure actuated switches for every requirement.* With these reliable instruments, we are eliminating chances of failure.

MELETRON® CORPORATION
950 NORTH HIGHLAND AVENUE, LOS ANGELES 38, CALIFORNIA

J. M. WALTHEW CO., Boeing Field, Seattle. THOMSON ENGINEERING SERVICE, 708 Hemphill St., Fort Worth and 732 So. Broadway, Wichita. ROUSSEAU CONTROLS Ltd., 2215 Beaconsfield Ave., Montreal 28, Canada. W. M. HICKS & J. A. KEENETH, 29-27 Forty-first Avenue, Long Island City, New York. JOSEPH C. SORAGHAN & ASSOCIATES, 1612 Eye St., Northwest, Washington 6, D.C.

Paint Coating Thickness Meters. I, II. R. Quarendon. *The Engr.*, July 31, Aug. 7, 1953; pp. 130, 162. Methods of calibration; design, accuracy, and limitations of different types; applications and special coating problems.

Protective Coatings on Metals; Increase Life at High Temperatures. D. M. Dovey and K. C. Randle. *Metal Treatment*, Aug., 1953, p. 341. Review of methods, applications, and potentialities of development.

Spray Finishing for Aircraft. Aerograph Co. Ltd. *J. SLAE*, July, 1953, p. 7. Analysis of critical control of material application, techniques, and equipment.

Metals & Alloys

The Brittle Fracture of Metals. E. O. Hall. *J. Mech. & Phys. Solids*, July, 1953, p. 227. 13 refs.

Creep and Recovery in Metals. A. J. Kennedy. *Brit. J. Appl. Phys.*, Aug., 1953, p. 225. Review of available experimental data; relation of stress and temperature factors on the behavior of structures and machines.

A Dictionary of Metallurgy. XIX—Hi-Il. A. D. Merriman and J. S. Bowden. *Metal Treatment*, Aug., 1953, p. 353.

Eine Theorie des Kriechens Von Einkristallen. O. G. Folberth and A. Kochendörfer. *J. Mech. & Phys. Solids*, July, 1953, p. 244. 24 refs. In German. Extension of Kochendörfer's theory of plastic deformation to cover behavior completely from creep to impact deformation.

Experiments with a Laboratory Extrusion Apparatus Under Conditions of Plane Strain. N. W. Purchase and S. J. Tupper. *J. Mech. & Phys. Solids*, July, 1953, p. 277. Metallic behavior and plastic flow problems.

A New Method for Determining the Yield Criterion and Plastic Potential of Ductile Metals. R. Hill. *J. Mech. & Phys. Solids*, July, 1953, p. 271.

On the Indentation Hardness. Yūzō Nakagawa. *Japan Sci. Rev.*, Apr., 1952, p. 297. Experimental analysis of plastic deformation and degrees of hardness of tool steels and other materials.

Materials Engineering File Facts: Granular Powders for Powder-Metallurgical Applications. *Materials & Methods*, Aug., 1953, p. 127. Includes table of production method or particle shape, mesh size, purity, and names of suppliers.

Measurement of Particle Size of Fine Ferromagnetic Powders. A. D. Franklin, R. Campbell, and J. Weinman. *J. Appl. Phys.*, Aug., 1953, p. 1040. 25 refs. ONR-supported experimental investigation of properties, using an electron microscope, X-ray line broadening, and nitrogen absorption techniques.

Subsieve Particle-Size Measurement of Metal Powders by Air Elutriation. Rolla E. Pollard. (*Research Paper 2428.*) *U.S., NBS J. Res.*, July, 1953, p. 17. 15 refs. The Roller air-analyzer method and testing procedure.

Metals & Alloys, Ferrous

Cracking Temperature of Mild Steel Arc Welds During Cooling. Takuro Kobayashi. *Japan Sci. Rev.*, Apr., 1952,

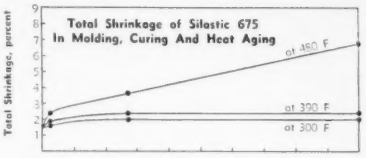
DOW CORNING

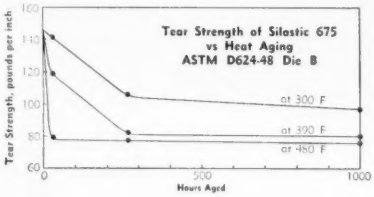
Silicone News

No. 3 of a Series • PUBLISHED BY DOW CORNING CORPORATION, MIDLAND, MICHIGAN

Remarkably Low Compression Set And Low Shrinkage Characterize New Extreme Temperature Silastic*

Silastic 675, a newly developed molding stock, has a combination of properties that is unique even among silicone rubbers. Serviceable from —100 to 500 F, Silastic 675 exhibits the lowest compression set of any extreme temperature silicone rubber. After 22 hours at 300 F, for example, compression set of this new molding stock is in the range of 15 to 20%; after 70 hours, 20 to 28%.





Silastic 675 is well suited for use in applications where low shrink in service is essential. Total shrinkage of molded test samples is below 2.5% after 1000 hours at 400 F; less than 7% after 1000 hours at 480 F. This low shrinkage characteristic also makes it possible to fabricate parts for many applications in the same molds used to form conventional organic rubber stocks.

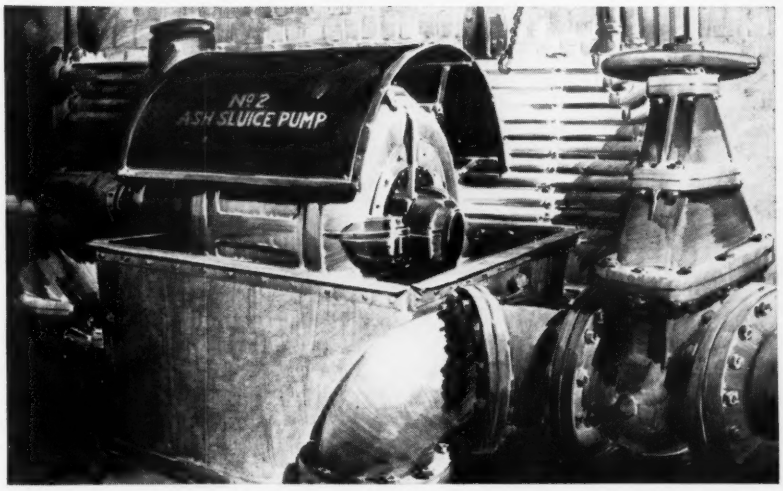
Silastic 675 also has good dielectric properties. Dielectric strength is 550 volts per mil. Measured at 10^2 cycles, dielectric constant is 3.07 and power factor is 0.0032. After seven days at 25 C and 100 percent humidity, surface resistivity of Silastic 675 is 2.82 at 10^{13} ohms and volume resistivity is 8.58 x 10^{13} ohms.

In addition to its low set, low shrink and excellent dielectric properties, Silastic 675 contains no toxic additives. It can safely be used to fabricate parts which come in contact with cosmetics, food and pharmaceuticals.

Silastic 675 is therefore singularly well suited to the fabrication of resilient gaskets, seals, O-rings, bellows, switch boots and dielectric fittings and connectors. It is one of the most versatile silicone rubber stocks available. It also opens new markets that have been inadequately supplied with parts molded of either organic or silicone rubber stocks.

No. 22

* T. M. REG. U. S. PAT. OFF.



WORLD'S LARGEST UTILITY COMPANY SPECIFIES SILICONE (CLASS H) INSULATION FOR RELIABILITY

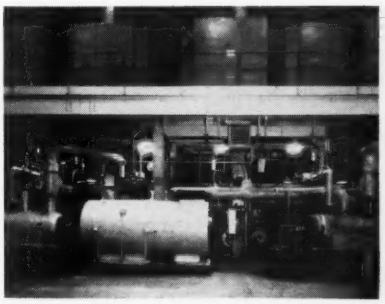
When millions of customers depend on you for 24 hour a day service, you can't take chances with your equipment. That's why the Consolidated Edison Company of New York took action when a 350 hp Class A insulated sluice pump motor failed three times in one year.

Although repeated overloading was the primary cause of failure, ambient temperatures were kept high by an enclosure built around the motor for flood protection. Failure rate was cut to once a year by rewinding with Class B insulation. The motor was then rebuilt with Class H insulation made with Dow Corning silicones. That was 9 years ago, and it is still in service.

That was Consolidated Edison's first experience with Class H insulation. Since then, many other motors have been rewound with Class H to withstand tough operating conditions. Over 79% or 71,700 out of a total of 90,500 horsepower in new motors bought for major auxiliary installations have been Class H insulated.

In buying new Class H equipment, they found that the frame size of motors rated at 200 hp or more could be reduced to such an extent that manufacturing economies often resulted in getting the added life and reliability of Class H insulation at no increase in total cost. Many solenoid coils and replacement coils for motors are also insulated with Class H materials.

Consolidated Edison has also pioneered the use of Class H insulation in sealed dry-type unit substation transformers.



They estimate that the cost of such units is more than competitive with conventional installations for power plant auxiliary supply. Convenient and safe, the Class H transformers can be located almost anywhere. And the cost of cable, switchgear, fire protection and related equipment is greatly reduced. That's why Consolidated Edison has already bought eighty-one 1250 KVA Class H transformers for unit substation work, and twelve 1000 KVA units for miscellaneous light and power.

(continued pg. 2)

(ADVERTISEMENT)

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING Silicone News

NEW DEVELOPMENT AND TECHNICAL DATA

For copies of any of the publications reviewed in this column or for data relating to any of the articles printed in this issue of the Dow Corning Silicone News, simply circle the corresponding reference number on the coupon below.

New pressure sensitive adhesives that stick to almost any material remain serviceable and can be applied at temperatures from —67 to 480 F. Uses include bonding silicone treated electrical insulating materials, sealing and wrapping tapes and assembly of small electronic parts prior to mechanical installation. *No. 25*

●

A reprint from Precision Metal Molding magazine describes various applications of silicone die lubricants in metal fabricating. Article includes information on effectiveness, concentrations used and methods of application. *No. 26*

●

Heat-stable, nonflammable, foamed structures can be produced from two new Dow Corning expansible resins. Such structures resist direct flame and thermal shock; undergo practically no structural or dimensional change at 700 F; show less than 0.05 percent moisture absorption after 7 days at 96 percent relative humidity. Both resins can be expanded to densities of 6 to 24 pounds per cubic foot. *No. 27*

●

Leather footwear, linemen's belts and gloves, and sporting goods, treated with Dow Corning 1109, remain water repellent for long periods of time; show greater resistance to oils and many chemicals. Silicone water repellent treatment does not impair "breathing" characteristics of leather. *No. 28*

●

Over 80 rubber companies, ready to make Silastic parts to your specification, are included in a revised listing of Silastic Fabricators. *No. 29*

●

For dependable service under the severe operating conditions frequently encountered in power distribution, welding and electronic applications, Class H transformers may be obtained from the companies included in the list of nearly 100 manufacturers of Class H Transformers. *No. 30*

●

"Tall Tales and Fabulous Facts" is a new 24-page booklet in which a parallel is drawn between the tall tales our ancestors told about such legendary characters as Paul Bunyan, Davy Crockett and Pecos Bill and some of the equally fabulous facts about Dow Corning silicone products. *No. 31*

DOW CORNING CORPORATION - Dept. AI-11
Midland, Michigan

Please send me: 22 23 24 25 26 27 28 29 30 31

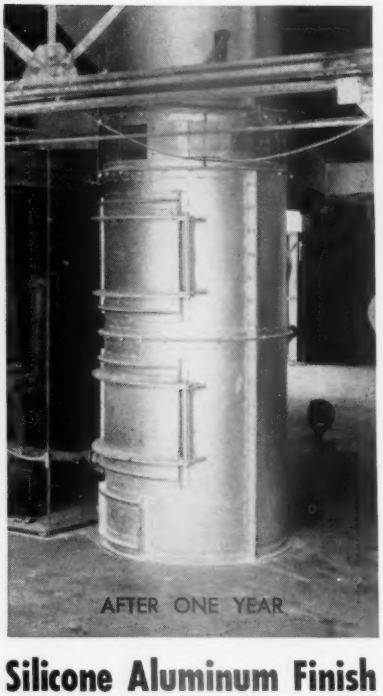
NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____



Silicone Aluminum Finish On Cyclone Furnace Intact After 4 Years At Temperatures From 70 to 1400 F

In the manufacture of perlite, a lightweight plaster aggregate, Panacalite Pacific Inc., of Los Angeles expands crushed volcanic rock in a cyclone furnace. Originally the furnace stood outside, exposed to the weather. Four times a day it was charged, raising its surface temperature from 70 F to 1400 F.

Three different attempts were made to protect the furnace with aluminum pigmented organic paints. Each application failed completely in a few hours.

Then in December, 1949, the furnace and its hopper were sandblasted, treated with a phosphoric solution and painted with a silicone-aluminum finish, Dutch Boy No. 5542, formulated by the Pacific Coast Branch of the National Lead Company. Exposed to the weather for a year, including rain which fell when the surface was at peak temperature, the finish was still in excellent condition when a building was erected around the furnace and the photo at left was taken.

The second photograph was taken 3 years after the building was constructed. No repainting or other maintenance has been done to date. After 4 years service, the silicone based finish has suffered no visible deterioration or loss of film continuity. *No. 23*

CLASS H RELIABILITY *continued*

That's the attitude that a steadily increasing number of engineers and management men are taking toward Class H insulation made with Dow Corning silicones. Used to uprate equipment by as much as 50% or extend its service life more than 10 times, Class H gives maximum efficiency and maximum reliability at surprisingly little more cost than the next best class of insulation. *No. 24*

DOW CORNING CORPORATION
First in Silicones
Atlanta
Chicago
Cleveland
Dallas
Detroit
MIDLAND, MICHIGAN
Los Angeles
New York
Washington, D. C.
(SILVER SPRING, MD.)
In Canada: Fiberglas Canada Ltd., Toronto
In England: Midland Silicones Ltd., London

Manufacturers of
Silicone Fluids
Silicone Abhesives
Silicone Adhesives
Silicone Release Agents
Silicone Compounds
Silicone Greases
Silicone Water Repellents
Silicone Bonding Resins
Silicone Electrical Insulating Resins
Silicone Molding Compounds
Silicone Expansible Resins
Silicone Defoamers
Silastic

p. 287. X-ray-defraction-method analysis of crystal fragmentation or lattice distortion on the surface of cracks to estimate cracking temperatures.

Influence of Oxygen on the Properties of Iron and Steel. Taiichi Saito. *Japan Sci. Rev.*, Apr., 1952, p. 349.

An Investigation on Peening. P. L. Calamari, F. J. Crum, and G. W. Place. *Welding J. Res. Suppl.*, Aug., 1953, p. 387–s. Analysis of effects on mild steel plate and deposited weld metals applying results of Charpy impact and hardness tests.

The Preparation in Sheet Form of Large Single Crystals of Silicon-Iron of Predetermined Orientation for Magnetic Purposes. R. G. Martindale and D. A. Langford. (*IEE Measurements Sect. Paper 1525.*) *Proc. IEE, Part II*, Aug., 1953, p. 417. 36 refs.

Russian Steels Today. Carl A. Zapffe. *Materials & Methods*, Aug., 1953, p. 79. Properties, compositions, and applications of commonly used grades.

Surface Conditions and Mechanical Properties. II. Howard E. Boyer. *Steel Processing*, Aug., 1953, p. 383. Analysis of composition and grain structure of steel; fatigue-strength testing.

Welding Metallurgy of Nodular Cast Iron. Edward E. Hucke and Harry Udin. *Welding J. Res. Suppl.*, Aug., 1953, p. 378–s. Structure of heat-affected zones under heat treatments.

Metals & Alloys, Nonferrous

How to Select Connectors for Aluminum Conductors. Henry Dupre. *Materials & Methods*, Aug., 1953, p. 96. Adaptability of properties; design aspects; corrosion and other problems.

Les Matériaux Réfractaires Modernes; Le Mixte Alumine-Chrome ou "Chromal." S. Tacvorian. *La Recherche Aéronautique*, May-June, 1953, p. 51. In French. ONERA investigation of refractory materials; study of the properties of aluminum-chrome alloys and of the calcination process; applications.

A Note on the Portevin-Le Chatelier Effect. A. H. Cottrell. *Philos. Mag.* (*7th Ser.*), Aug., 1953, p. 31. 18 refs. Plastic deformation study of aluminum alloy.

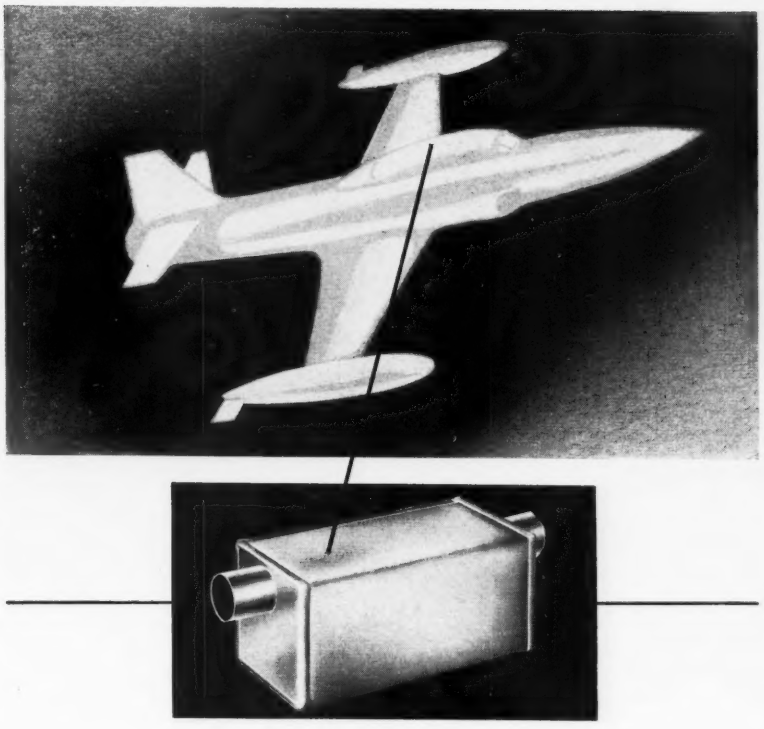
The Spontaneous Magnetization of Alloys. I—Copper Nickel Alloys. D. J. Oliver and W. Sucksmith. *Proc. Royal Soc.* (*London*), *Ser. A*, Aug. 11, 1953, p. 1. 20 refs. Experimental investigation to determine temperature variations of spontaneous magnetization of various ferromagnetics.

Strength of Copper at Elevated Temperatures. H. L. Burghoff. *Elec. Mfg.*, Sept., 1953, p. 143. Summary of results of a 10-year investigation of tensile creep properties measured at 300–500°F.

The Yield Stress of Pure Lead in Compression. N. Loizou and R. B. Sims. *J. Mech. & Phys. Solids*, July, 1953, p. 234.

Industry Looks at Lithium. H. C. Meyer, Jr., Compiler. *Foote Prints*, No. 1, 1953. 24 pp. 83 refs. Survey of properties, applications, and potentialities.

On Tin Whiskers. F. C. Frank. *Philos. Mag.* (*7th Ser.*), Aug., 1953, p. 854. A theoretical discussion of disloca-



New ISC HIGH VELOCITY AIR LINE MUFFLER WHIPS JET COCKPIT WHINE

The shrill whine of cockpit air conditioning equipment is a threat to pilot comfort and ease of communications. Now, ISC has solved this annoying problem with a midget, lightweight muffler which fits easily into any existing aircraft air conditioning system.

Giving up to 20 decibels broad band attenuation, the ISC High Velocity Air Line Muffler measures only 5" square by 10" long and weighs only 3½ pounds.

Constructed of steel-lined aluminum, it is rugged as well as compact. It will operate at temperatures of 500° F and above. Incorporating the Soundstream principle, the muffler produces amazing noise reduction with only a minimum pressure drop.

The High Velocity Air Line Muffler is another ISC FIRST in the field of aviation sound control. Why not bring YOUR noise problem to ISC now!

For further details on the ISC High Velocity Air Line Muffler, write to:

ENGINEERING DEPT.
INDUSTRIAL SOUND CONTROL, INC.
45 GRANBY STREET,
HARTFORD, CONN.

SILENCE SERVICE

Industrial Sound Control Inc.
45 Granby Street, Hartford 12, Conn.
2119 SO. SEPULVEDA BLVD., LOS ANGELES, CALIF.

tion and deformation twinning of such metals as tin and cadmium subjected to very high bending stress.

Determination of Impurities in Titanium Metal. J. M. Thompson. *Anal. Chem.*, Aug., 1953, p. 1231.

Research Findings on Brazing and Soldering Titanium. H. L. Meredith. *Auto. Ind.*, Aug. 15, 1953, p. 34.

Properties and Applications of High Purity Iodide Ductile Zirconium. W. M. Raynor. *Foote Prints*, No. 2, 1952, p. 25.

Nonmetallic Materials

New Paper Materials—Properties and Uses. E. E. Frazier. *Materials & Methods*, Aug., 1953, p. 92.

Unplasticized PVC. George S. Laaff. *SPE J.*, Sept., 1953, p. 14. Corrosion-resistant properties and other chemical characteristics of unplasticized polyvinyl chloride; applications.

Where Plastics Are Used in Air Liners. Harold H. Rosenbaum. *Materials & Methods*, Aug., 1953, p. 100.

Effect of Temperature Upon Rate of Oxidation of Rubber; Nature of Resultant Deterioration. J. Reid Shelton, Fred J. Wherley, and William L. Cox. *Ind. & Eng. Chem.*, Sept., 1953, p. 2080. 17 refs.

Second-Order Transitions of Rubbers at High Pressures. Charles E. Weir. (*Research Paper 2420.*) *U.S., NBS J. Res.*, June, 1953, p. 311. 20 refs. Experimental significance of pressure-volume-temperature data on rubber-sulfur vulcanizates.

Thermodynamics of the Rubber-Sulfur System at High Pressures. Charles E. Weir. (*Research Paper 2421.*) *U.S., NBS J. Res.*, June, 1953, p. 321. Further analysis of experimental data for values of work, heat, internal-energy change, and difference in specific heat.

Testing

The Adaptation of an Electron Microscope for Reflexion and Some Observations on Image Formation. M. E. Haine and W. Hirst. *Brit. J. Appl. Phys.*, Aug., 1953, p. 239. Application to examination of surface conditions of various materials.

A Combined Dilatometer-Electrical Resistivity Apparatus for Investigating the Sintering of Metal Powder Compacts. N. A. McKinnon. *Australia, ARL Rep. SM. 205*, Apr., 1953. 24 pp.

Emission Spectrographic Analysis in Industry. Robert W. Smith. *GM Eng. J.*, June-July, 1953, p. 11. Qualitative and quantitative analytic procedures; applications.

Industrial Radiography. R. E. MacDonald. *Eng. J.*, Aug., 1953, p. 1003. 31 refs. Description of equipment; applications include testing of metals for weld surface and subsurface defects.

Measurement of Elastic Constants at Low Temperatures by Means of Ultrasonic Waves—Data for Silicon and Germanium Single Crystals, and for Fused Silica. H. J. McSkimin. *J. Appl. Phys.*, Aug., 1953, p. 988. 27 refs.

Touchdown and GO!

"Here is the answer..." said a distinguished military leader as he witnessed Chase Assault Transports deliver troops, vehicles and weapons to forward combat areas ***by landing in unprepared fields.***

But this answer was not found by modifying existing planes; such attempts failed miserably. Chase planes are designed especially to provide the answer. They represent a noble accomplishment by the Air Force-Army-Chase team—an accomplishment which replaces, as the primary means of delivery, the less reliable, more costly, more hazardous techniques which were developed for interim use.

Delivery of troops is fast, safe with Chase planes. It's touchdown and **Go!**

Chase AIRCRAFT CO., Inc.
WEST TRENTON, NEW JERSEY
STROUKOFF AVITRUC

To keep pace with the rapid development of faster, higher-performance aircraft, General Electric engineers have developed a . . .

New G-E Flight Control System Designed For Tomorrow's Aircraft

The new General Electric FC5 Flight Control System was developed to meet the stability and flight control requirements of advanced planes which will roll off production lines beginning in 1955.

The FC5 represents new engineering concepts beyond the currently successful G-E systems now installed in the Navy's Chance-Vought F7U-3 Cutlass, Douglas F3D-2 Skyknight, Grumman F9F-5P Panther and Grumman F9F-6P Cougar and the McDonnell F3H Demon.

CAN BE CUSTOM-DESIGNED

The FC5 is a fundamental system concept which can be custom-designed from a family of integrated components. The number of components, and in some cases their actual designs, can be varied to suit specific applications.

Designed to perform a wide range of functions, the FC5 can fulfill the relatively basic requirements of a single axis damper system or the many requirements of a fully automatic relief and maneuvering system including stabilization in all three axes.

RELIABLE AND LIGHTWEIGHT

Reliability and lightweight are only two of the FC5's design features. It will also incorporate 1) automatic pitch trim 2) "G" limiting in automatic modes of operation to prevent overstress of the aircraft during maneuvers 3) continuous synchronization of autopilot during manual maneuvers 4) immediate pilot take-over at any time—through the stick and rudder pedals—with no transient in the system. The FC5 also has been designed to operate in conjunction with bombing, fire control, navigation and ground control systems.

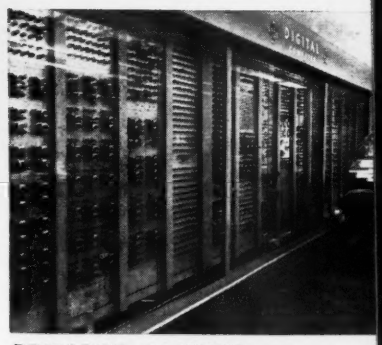
FC5 BULLETIN AVAILABLE

The FC5 is another in the long line of G-E products engineered by the men who know the needs of the aviation industry. If you would like more information on the FC5 system, write for bulletin GEA-6039. Section 210–84, General Electric Company, Schenectady 5, N. Y.

You can put your confidence in—

GENERAL ELECTRIC

ENGINEERING SPECIALISTS at G.E. work as a team constantly improving present equipment and outlining future system plans.



RESEARCH FACILITIES include both analog and digital computers for complete analysis of the performance of systems and their components.

FLIGHT TESTING at G.E.'s Flight Test Center, Schenectady, N. Y., keeps new developments abreast of the requirements of higher-performance planes.

G-E AUTOPILOTS are now in operational use in some of the Navy's hot planes and are being installed in a new one—the McDonnell F3H Demon.

Metallurgical Examination in the Works Laboratory. D. Cumbers. *J. SLAE*, July, 1953, p. 3. Visual and microscopic testing of metals.

On the Validity of Assumptions Made in Theories of Plastic Flow for Metals. Joseph Marin and L. W. Hu. *Trans. ASME*, Aug., 1953, p. 1181; Discussion, p. 1186. Biaxial stress analysis of 14S-T6 aluminum alloy.

Recently Developed Methods to Detect Defects in Forgings and Castings. Robert M. Baker. *GM Eng. J.*, June-July, 1953, p. 59. Use of ultrasonic waves to detect internal irregularities in metallic structure.

Ultrasonic Inspection of Welded Pressure Vessels. *The Engr.*, Aug. 14, 1953, p. 199. Test principles, with applications; techniques and experiences of W. F. Fraser and Co., Ltd.

Mathematics

Analyzing Nonlinear Servos by "Linearizing" the Performance Equations. James M. Nightingale. *Mach. Des.*, Aug., 1953, p. 139.

Eigenvectors of Matric Polynomials. Murray Mannos. (*Research Paper 2429.*) *U.S., NBS J. Res.*, July, 1953, p. 33.

Moments of Area of Irregular Plane Figures. H. G. Edmunds. *The Engr.*, Aug. 14, 1953, p. 213. Graphic computation method based upon the use of transparent overlays having grid lines with appropriate scale and spacing.

On the Mathematics of Exchange Processes in Fixed Columns. I—Mathematical Solutions and Asymptotic Expansions. II—The Equilibrium Theory as the Limit of the Kinetic Theory. S. Goldstein. *Proc. Royal Soc. (London), Ser. A*, Aug. 25, 1953; pp. 151, 171. 42 refs.

On the Numerical Solution of Parabolic Partial Differential Equations. Gertrude Blanch. (*Research Paper 2424.*) *U.S., NBS J. Res.*, June, 1953, p. 343. Study of the most economical mesh ratio for a given approximation formula.

A set of Principles to Interconnect the Solutions of Physical Systems. Gabriel Kron. *J. Appl. Phys.*, Aug., 1953, p. 965. Includes a detailed solution of a boundary value problem of Poisson's equation and of mathematical methods using electric circuit models.

Meteorology

An Experimental Study of the Relation Between Airplane and Wind-Vane Measurements of Atmospheric Turbulence. H. B. Tolefson, K. G. Pratt, and J. K. Thompson. *U.S., NACA RM L52L29b*, July 17, 1953. 20 pp.

On Anomalous Winds in the Free Atmosphere. A. F. Gustafson. *Bul. AMS*, May, 1953, p. 196. USAF-sponsored upper-atmospheric studies at UCLA.

The Radar Detection of Dangerous Storms. R. E. Perry. *J. Inst. Navigation*, July, 1953, p. 238.

Radar Echoes from a Growing Thunderstorm. Raymond Wexler. *J. Meteorology*, Aug., 1953, p. 285. Analysis of the theoretical growth of hail and the behavior of the first radar echo in a cumulus cloud; comparison between theory and observations.

Some Possible Reductions in Gust Loads Through Use of Radar in Transport Airplanes. H. B. Tolefson. *Bul. AMS*, May, 1953, p. 187. NACA analysis of turbulence measurements and other factors.

Raindrop Charge and Electric Field in Active Thunderstorms. Ross Gunn and Charles Devin, Jr. *J. Meteorology*, Aug., 1953, p. 279.

The Stability Properties and Structure of Disturbances in a Baroclinic Atmosphere. H. L. Kuo. *J. Meteorology*, Aug., 1953, p. 235. USAF-sponsored research at MIT.

Military Aviation

Flying Triangles. Joseph Bonanno. *Ordnance*, Sept.-Oct., 1953, p. 354. Development of delta-wing aircraft for aerial combat.

Missiles

A Flight Investigation of the Effect of Steady Rolling on the Natural Frequencies of a Body-Tail Combination. Norman R. Bergrun and Paul A. Nickel. *U.S., NACA TN 2985*, Aug., 1953. 27 pp.

Guided Midget; M.L. Aviation's Radio-controlled Target Aircraft. *Flight*, Aug. 28, 1953, p. 254, cutaway drawing. Design specifications and performance data.

The "Off-Axis" Telescope; A New Ordnance Development for Tracking Test Missiles. E. E. Simmons. *Ordnance*, Sept.-Oct., 1953, p. 352. For research use at White Sands Flight Determination Lab.

Navigation

The Operation and Navigation of Jet Airliners. R. C. Alabaster. *J. Inst. Navigation*, July, 1953, p. 213; Discussion, p. 231. Flight path of the Comet and cruise control problems, with appendixes on jet-engine and airframe characteristics and the principle of the Machmeter.

Recent Developments in the Study of Bird Navigation. G. V. T. Matthews. *J. Inst. Navigation*, July, 1953, p. 264. 21 refs.

Ordnance & Armament

Aircraft Rocket Launchers; Continuing Developments in Mounting Aërial Armament. Arthur L. Schoeni. *Ordnance*, Sept.-Oct., 1953, p. 348.

Parachutes

This Way Out; Some Thoughts on Parachuting Technique. T. W. Willans. *Flight*, Aug. 14, 1953, p. 191.

Power Plants

Efficiency Standards for Heat Engines. C. Roseti. (*Tecnica Italiana*, Apr.-May, 1953, p. 165.) *Engr. Dig.*, Aug., 1953, p. 289. Analysis of reciprocating, gas-turbine, and other engine types with internal or external heat generation.

New Data on Automotive Combustion; Research on the Nature of Engine Knock. *U.S., NBS Tech. News Bul.*, Aug., 1953, p. 113. NBS autoignition studies.

Recent Developments in "Knock" Research. D. Downs and R. W. Wheeler. *IME Auto. Div. Proc., Part III*, 1951–52, p. 89; Discussion, p. 121. 31 refs. Review of published data on the mechanism of autoignition and other combustion problems; includes NACA high-speed photographic investigations.

Recent Developments in Sub-Zero Engine-Starting. Fred A. Traino. *Auto. Ind.*, Aug. 15, 1953, p. 52. WADC and other research investigations on various air- and liquid-cooled engines.

Jet & Turbine

Evaluating Moments of Inertia by Graphical Techniques. Joseph Modrovsky. *Mach. Des.*, Aug., 1953, p. 185. Structural analysis of a turbine blade profile.

An Experimental Single-stage Air-cooled Turbine. I—Design of the Turbine and Manufacture of some Experimental Internally Cooled Nozzles and Blades. J. Reeman and R. W. A. Buswell. *Aircraft Eng.*, Aug., 1953, p. 227.

The Measurement of Blade-Tip Clearances in Aircraft Turbines by a Capacitance Method. I. A. Mossop and F. D. Gill. (*IEE Measurements Sect. Paper 1319.*) *Proc. IEE, Part II*, Aug., 1953, p. 377; Discussion, p. 384.

Afterburners—Are They Worth While? Floyd C. Newton. *Aero. Eng. Rev.*, Oct., 1953, p. 42. (Also in *The Aeroplane*, Sept. 11, 1953, p. 393.) Analysis of thrust augmentation problems, with performance requirements.

Water Injection; What It Is—and What It Does. E. S. Moult. *de Havilland Gazette*, Aug., 1953, p. 128. The Ghost 50 MK. 2-combustion chamber injection system for thrust augmentation.

Rocket

Liquid Fuel Rockets. R. A. Fry. *J. SLAE*, July, 1953, p. 12. Propulsion principles of jet-reaction engines, including an analysis of combustion, expansion nozzle, and other requirements.

Production

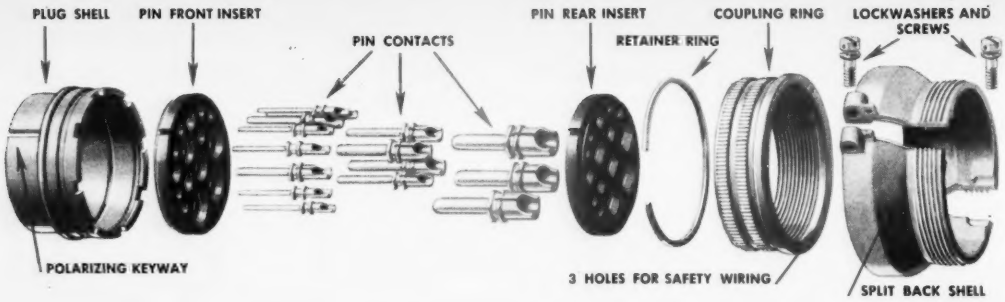
Air Power for Peace. DeWitt C. Ramsey. *AIAA Paper*, Aug. 28, 1953. 14 pp. Future research and development possibilities for the aircraft industry.

The Manufacture and Inspection of Aerofoil Models. R. S. Marriner. *The Engr.*, Aug. 14, 1953, p. 202. Method to produce small wind-tunnel airfoils by machining of enveloping tangential planes.

A New Conception of Production. Walter Puckey. *The Aeroplane*, July 31, 1953, p. 133. Discussion of industrial, technologic, and research problems.

Optical Methods Simplify Tooling Problems. Andrew E. Rylander. *Tool Engr.*, Sept., 1953, p. 42. Accurate and flexible methods of alignment and measurement techniques applied to air-frame fabrication.

GOLD PLATED CONTACTS
NOW STANDARD ON ALL
AMPHENOL
AN CONNECTORS
GOLD PLATED CONTACTS
GOLD PLATED CONTACTS
GOLD PLATED CONTACTS



AMPHENOL has long been the leading manufacturer of approved A N connectors—and every AMPHENOL A N connector is made to government specifications. Under these specifications, however, many alternate processes in manufacture are allowed. Where this choice is given, AMPHENOL has *always* gone to the highest quality interpretation. Thus, many features of AMPHENOL A N connectors exceed the basic requirements of the specifications and are unique with AMPHENOL.

AMPHENOL's pioneer work in improving A N connectors has often been recognized by the inclusion of AMPHENOL-developed changes in government specifications. The 1-501 blue dielectric and gold-plated contacts are examples of how AMPHENOL initiative has resulted in *better* A N connectors.

CADMIUM SHELLS The connector shells on all AMPHENOL A N's are cadmium plated with a chromate conversion coating. The shell finish is available in either bright cadmium or olive drab. The cadmium plate with chromate conversion coating has excellent conductivity and surpasses all military specifications for corrosion resistance. In the olive drab finish the connectors are non-reflecting.

1-501 BLUE DIELECTRIC AMPHENOL A N connectors use as dielectric the new 1-501 diallyl phthalate resin-based molding compound. Developed by AMPHENOL, this material combines the specific requirements of nearly perfect dimensional stability, high insulation resistance in the presence of high temperatures and high humidity combined, and high arc resistance. 1-501 has a lifetime shrinkage of less than 0.3%.

GOLD PLATED CONTACTS The newest improvement on AMPHENOL A N connectors, and one of the most significant, is the conversion to gold-plated contacts. Now standard on all AMPHENOL A N connectors, gold-plated contacts have many advantages, including superior contact surfaces, an end to the problem of oxidation and easier, faster soldering. Gold-plated contacts on A N connectors are unique with AMPHENOL and may be obtained only by the specification of AMPHENOL.

AMPHENOL CATALOGING Because of the diversity of the AMPHENOL line, there is a variety of catalogs and allied literature published by AMPHENOL.

For general information about the AMPHENOL line, *Catalog* B will prove most useful. Where more specific information is required, *Catalog* A, A N connectors and fittings, and *Catalog* D, R F cables and connectors, should be requested. *Catalog* C is an "OK Methods Manual" of instructions for proper assembly of cables and connectors. As these four catalogs are being continually revised and brought up to date, a new suffix number is attached to the catalog letter for each issue. In all cases, a request for catalogs will produce only the latest issue.

Among the special literature published by AMPHENOL are the *Engineering News*, new products listings, RF Cable and Connector *Selector*. Slide Rule and miscellaneous bulletins on new AMPHENOL components.

AMPHENOL

AMERICAN PHENOLIC CORPORATION Chicago 50, Illinois

Amform 2288-103325 Printed in U.S.A.

Producing the Sabre at Commonwealth Aircraft. Ian H. Ring. *Aircraft* (Australia), July, 1953, p. 28.

Production of the Canberra Jet Bomber in Australia. N. W. Hodgson. *Aircraft* (Australia), July, 1953, p. 22.

Special SBAC Issue: Britain's Aircraft Industry. *Flight*, Sept. 4, 1953. 271 pp., cutaway drawings, charts, tables, diagrams. Partial contents: British Aircraft, 1953. Aircraft, Tabulated Data. Tabulated Engine-Data. The Aircraft Industry Directory. Proprietary Euipment.

Technical Aspects of Production. J. V. Connolly. *The Aeroplane*, Aug. 14, 1953, p. 200. Problems and possibilities in the aircraft industry.

Metalworking

Automatic Controls for Surface Finishing Jet Engine Parts. R. J. Thomas. *Auto. Ind.*, Sept. 1, 1953, p. 48.

Contour Cutting. Ralph H. Eshelman. *Tool Engr.*, Sept., 1953, p. 67. Operational procedures and equipment; applications.

Deep-Hole Boring. II—Oil Pressure-Heads: Existing German and Swedish Boring Machines. H. J. Pearson. *Aircraft Prod.*, Sept., 1953, p. 318.

Deep-Hole Drilling. George A. Wilson, Jr. *Mach. Des.*, Aug., 1953, p. 178. Design of a low-cost process.

Electrospark Machining. C. R. Alden. *Mech. Eng.*, Sept., 1953, p. 701. 13 refs. Review of developments, potentialities of processes, and applications.

Large-Scale Profiling; Manually-Operated, Two-Dimensional Machine for Large Airframe-Fittings for More-Rapid Form-Filling. *Aircraft Prod.*, Sept., 1953, p. 342.

On the Mechanics of Cutting Metal Strips with Knife-Edged Tools. R. Hill. *J. Mech. & Phys. Solids*, July, 1953, p. 265.

Spin-Dimpling; Simple Equipment for Use in Portable Form or in Standard Drilling-Machines. *Aircraft Prod.*, Sept., 1953, p. 314. Vickers-Armstrongs, Ltd.'s methods and equipment.

Tensioned-Skin Construction; The Heal Method—Increased Stiffness with Reduced Weight; Double-Curvature Without Preforming. *Aircraft Prod.*, Sept., 1953, p. 351. Tests and applications of the technique; weight, cost, production efficiency, and other factors.

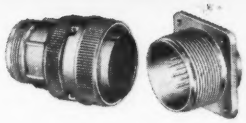
Turning with Oscillating Cutting Tools. S. G. Redko. (*Stanki i Instrument*, No. 3, 1953, p. 24.) *Engr. Dig.*, Aug., 1953, p. 291. Result of tests on an "unorthodox" method of metal cutting.

Design Problems of Large Aluminum Forgings. C. W. Andrews. *Auto. Ind.*, Aug. 15, 1953, p. 32. Configurations for desired thickness at low cost; weight-reduction factors.

A Discussion of Cold-Working of Metals. *GM Eng. J.*, June-July, 1953, p. 56. Survey of new techniques.

German Research in Drop Forging; Work at the Technological University of Hanover. Otto Kienzle. *Metal Treatment*, Aug., 1953 p. 361. Survey of activities and equipment.

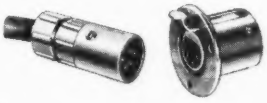
CANNON PLUGS —*the highest quality* —*greatest variety* —*widest use*



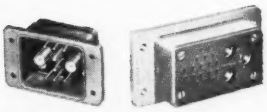
AN Designed to Air Force–Bureau of Aeronautics – requirements. Now widely used for all instruments requiring electrical circuits. Coupling nut connection and disconnection. Two plug types; 3 receptacles with variations and clamp accessories, in 15 shell sizes and more than 250 insert arrangements. A type for every need. Ask for "AN" Bulletin.

K & RK Designed for uses in aircraft, this versatile lightweight plug is widely used on a great variety of instruments and electronic equipment. Special acme coupling nut connection and disconnection. 8 contact sizes accommodate 16, 14, 10, 8, 6, 4, 2 and 0 AWG. Maximum 200a. 8 shell diameters. 204 insert variations. KH Series, hermetically sealed Type K, also available. Write for "K" Bulletin.

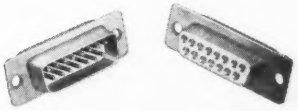
GS (AN) Designed for applications demanding hermetic sealing under high pressures in a temperature range from minus 300F to plus 600F. 2 basic shell designs. NEF threaded coupling nut. Steel shells and steel contacts. Mate with AN Series. See "AN" Bulletin or "GS" Bulletin.



XL For audio equipment and general electronic uses: 3 and 4 contact layouts, 10 and 15a; 17 shell designs; zinc and steel plug shells. Ask for "XL" Bulletin.

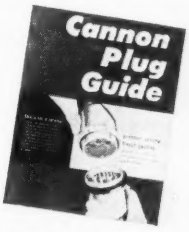


DPB-DPD For rack-and-panel installations, instrument panels and for any plug-in sub-assembly where both halves of the connector are rigidly mounted, or where one half is rigidly mounted and the other half cord mounted. 78 max. contacts, 200a maximum. Ask for "DP" Bulletin.



D SERIES SUB-MINIATURE PLUGS Designed to meet the miniaturization program. Used both as rack-and-panel disconnect and cord connectors for hand portable radio equipment, audio circuitry and related applications. Keystone shaped. 15 to 50 gold-plated contacts. DH hermetically sealed also available. See "D" Bulletin.

U SERIES SUB-MINIATURE PLUGS For hermetically sealed instruments, indicators, miniature switches, relays, transformers, amplifiers and other miniaturized sealed components. Steel shells & pin contacts; standard socket contacts in Silcan insulators. 1, 3, 6, 12 contact arrangements. 5a max. Bayonet lock coupling. See "U" Bulletin.



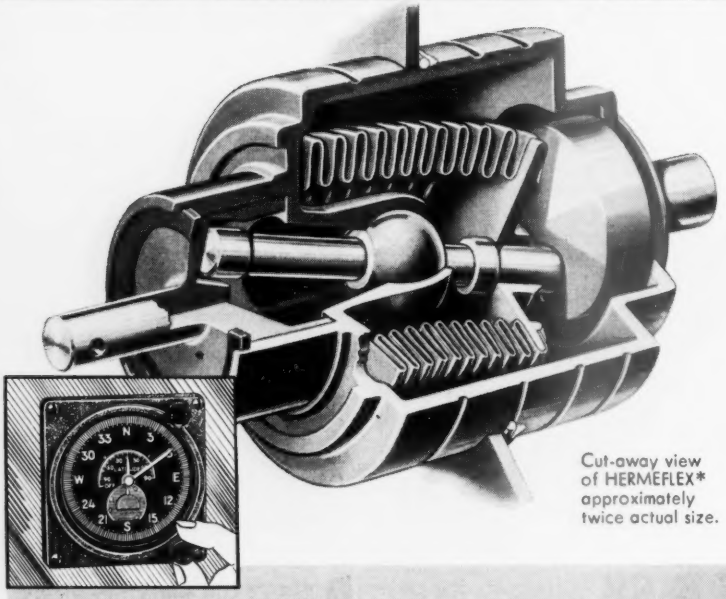
Send for a copy of the new Cannon Plug Guide.

CANNON ELECTRIC *Since 1915*

CANNON ELECTRIC COMPANY, LOS ANGELES 31, CALIFORNIA

Dept. K-105

HERMEFLEX*



Cut-away view of HERMEFLEX* approximately twice actual size.

. . . TRANSMITS ROTARY MOTION THROUGH A METAL-TO-METAL SEAL

Through the ingenious application of a toggle and metal bellows, the HERMEFLEX provides a positive metal-to-metal seal of shaft rotation through a wall of solid metal. Employing no gaskets nor sliding seals this device is a compact, unitized seal essential to the control of hermetically sealed instruments, electronic devices and high vacuum apparatus.

At present the HERMEFLEX is produced in two standard diameters—1-inch and ½-inch. These units are designed for the manual control of shaft rotation in pressure differentials up to 1 atmosphere. Your inquiries for HERMEFLEX developments to meet different duty cycles, special environmental conditions or other unusual problems, are cordially invited.

Bulletin will be sent upon request.

**PATENTED U. S. Patent Office. Trade name copyrighted.*

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Kearfott

SINCE 1917

CREATIVE ENGINEERING PRODUCTION ACHIEVEMENT

KEARFOTT COMPANY, INC., 1150 McBride Ave., Little Falls, N. J.
Midwest Office: 188 W. Randolph St., Chicago 1, Illinois
West Coast Office: 253 N. Vinedo Ave., Pasadena, Calif.
A General Precision Equipment Corporation Subsidiary

Light-Alloy Forging—Design and Production Problems as Related to Heavy-Press Operations. A. E. Favre. *Mech. Eng.*, Sept., 1953, p. 693. Alcoa's experience in air-frame production.

Extrusion: The Newest Metal Working Method in Industry. I. F. McCormick. *Steel Processing*, Aug., 1953, p. 379.

Panel Extrusions in Aircraft Structures. Howard Kastan. *Mech. Eng.*, Sept., 1953, p. 715. Evolution of structural design, proposals for development, and other factors.

Which Metal Form—Spun or Drawn? John W. Lengbridge. *Materials & Methods*, Aug., 1953, p. 87. Relative advantages and limitations; applications.

Effects of Electrodes and Heat Treatments on Mild Steel Weldments. I—The Effects of Welding Techniques and Electrodes. II—The Effects of Thermal Cycles of Welding. Ernest F. Nippes and Alexander Lesnewich. *Welding J. Res. Suppl.*, Aug., 1953, p. 353-s. 29 refs.

Factors Which Dictate the Design of Ferrous Welding Electrodes. D. L. Mathias. *Foote Prints*, No. 2, 1952, p. 7.

Fast Roll-Spot Technique Doubles Welding Speeds. J. R. Fullerton. *Auto. Ind.*, Aug. 15, 1953, p. 46.

Fillerarc Welding Process. R. W. Tuthill. *Welding J.*, Aug., 1953, p. 703. 18 refs. Developments and experimentation of new equipment for consumable electrode gas-shielded welding.

The Incidence of Cracking in Welding Type 347 Steels. L. K. Poole. *Welding J. Res. Suppl.*, Aug., 1953, p. 403-s. 14 refs. Analysis of characteristics and causes of micro-fissures and cracks.

Inert-Gas Metal-Arc Welding of Mild and Low-Alloy Steel. Frank G. Harkins. *Welding J.*, Aug., 1953, p. 683. Technique for aircraft quality steels; other physical aspects.

Joining Aluminum to Other Metals. Mike A. Miller. *Welding J.*, Aug., 1953, p. 730. 19 refs. Study of fusion welding, pressure welding, brazing, soldering, diffusion welding, and resin bonding; other aspects of processes.

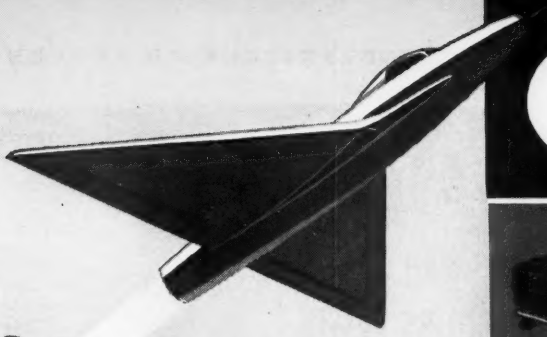
Restoration of Ductility in Alloy Titanium Welds. A. J. Rosenberg, E. F. Hutchinson, and S. Weiss. *Welding J.*, Aug., 1953, p. 708. Experimental investigation on RC-130A titanium-manganese alloy, with analysis of time-temperature transformations for heat treatment and optimum welding conditions.

Stranded Electrode Materials for Aircomatic Welding. Harold Robinson and Harry C. Cook. *Welding J.*, Aug., 1953, p. 692. Fabrication methods; deposit properties; applications.

Production Engineering

Designing Electrical Equipment for Production. Eugene E. Hansen. *Elec. Mfg.*, Sept., 1953, p. 116. Analyses of cost, time, and producibility factors applied to design and layout control.

Prediction of Development Effort. John McL. Reed. *Aero Dig.*, Aug., 1953, p. 17. 19 refs. Estimating industry's problems of experimental research, production time, testing, delivery, and other requirements.



Leadership in fuel metering...

FOR JET, RAMJET AND TURBO-PROP ENGINES

Since the first jets of World War II, Bendix Products Division at South Bend has served the aircraft industry in developing and manufacturing fuel metering systems for jet engines. Today Bendix offers unmatched know-how and facilities both in electronic and hydro-mechanical principles for these important components of jets, ramjets and turbo-prop engines.

RESEARCH • A staff devoted exclusively to seeking new and better fuel metering techniques – preparing today for the requirements of tomorrow.

ENGINEERING • An organization that is experienced in applying both *electronic* and *hydro-mechanical* principles. Successful creators of lightweight, serviceable equipment to meet the demands of each new advance in engine design.

MANUFACTURING • Two modern and geographically separate manufacturing divisions. Each capable of building to the most exacting test standards – high quality at reasonable cost.

SERVICE • A world-wide service organization that follows through to see that engine operators obtain full benefit from the quality built into the equipment.

EXPERIENCE • A background of more than thirty years of leadership in designing and building fuel metering systems for both reciprocating and jet engines.

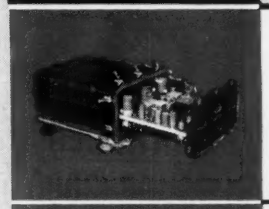
For Your Fuel Metering Requirements Depend Upon Bendix:

- Hydro-mechanical fuel controls
- After burner controls
- Fuel supply pumps
- Spray nozzles
- Electronic fuel controls
- Turbo-prop controls
- Flow dividers
- Ramjet controls

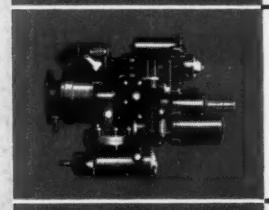
BENDIX PRODUCTS DIVISION SOUTH BEND INDIANA

Bendix Aviation Corporation

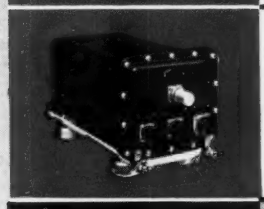
electronic



ELECTRONIC CONTROL Senses engine speeds, gas temperatures and other control factors—then signals fuel requirements to the fuel metering unit.

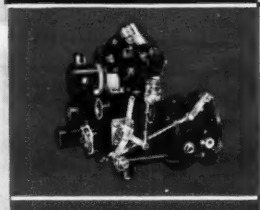


FUEL METERING UNIT Electrically controlled, this unit meters fuel to the engine in accord with signals from the electronic control.

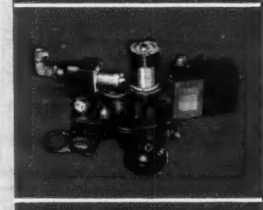


ELECTRONIC AMPLIFIER Maintains a scheduled exhaust turbine temperature by controlling the nozzle area.

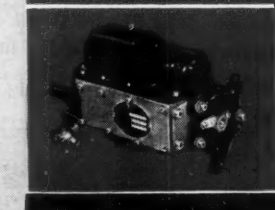
hydro-mechanical



MAIN FUEL CONTROL The control illustrated includes a governor which holds the engine at a selected speed regardless of altitude.



AFTERBURNER FUEL CONTROL Graduates the afterburner thrust by selecting fuel flow in various proportions to mass air flow through the engine.



NOZZLE CONTROL A hydro-mechanical servo control unit which actuates the variable exhaust nozzle mechanism of jet engine.

Bendix Products Division

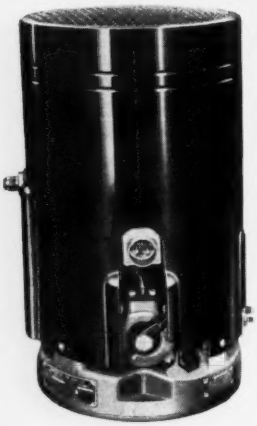
ELECTRONIC AND HYDRO-MECHANICAL CONTROLS

Export Sales: Bendix International Division
205 East 42nd St., New York 17, N. Y.

OPPORTUNITIES FOR ENGINEERS in Electronics, Mechanics and Hydraulics — This division of Bendix is among the world leaders in developing and manufacturing a wide variety of products currently in use by commercial as well as military aviation. Investigate your opportunities with Bendix. Write to Administrative Engineering, Bendix Products Division, Bendix Aviation Corporation, South Bend, Ind.

NEWMATICS

SELF-CONTAINED RHODES LEWIS
HIGH-PRESSURE (3000 psi) COMPRESSOR
SAVES SPACE, WEIGHT, MAINTENANCE



features: Integral package unit, requires only simple power source and reservoir connections . . . operates 500 hours continuous duty per Specification MIL-C-7135 . . . used extensively in military aircraft pneumatic systems . . . easy to install and service . . . takes less than five minutes to install or remove entire package unit. *Approved by U. S. Navy for installation in military aircraft.*

See Rhodes Lewis for these new light-weight products and systems

ITEM	Used in high-pressure pneumatic systems	Used in low-pressure pneumatic systems	Other aircraft applications
AC & DC Compressors	X	X	
Hydraulically Driven Compressors	X	X	
Bleed Turbine Compressors	X	X	
Fiberglass Pneumatic Receivers	X	X	
Electrical & Electronic Control Systems			X
AC & DC Motors	X	X	X
Small Accessory Turbine Drives	X	X	X
Pneumatic Valves, Operated Electrically or Mechanically	X	X	
Solenoids, Intermittent or Continuous Duty	X	X	X
Pneumatic Ejection Systems	X	X	

Take advantage of Rhodes Lewis engineering knowledge and manufacturing facilities in the field of electrical and pneumatic equipment. Your inquiries are cordially invited.

RHODES LEWIS CO.
Subsidiary of McCulloch Motors Corporation
6151 W. 98th Street,
Los Angeles 45, California

ELECTRIC PNEUMATIC ENGINEERS·MANUFACTURERS

5-3300

Quality Control—Communicating Data Effectively. W. W. Kauffman. *Tool Engr.*, Sept., 1953, p. 54. NAVORD experience and procedures.

Propellers

A Brief Survey of Progress on the Mechanics of Cavitation; An Addendum to DTMB Report 712, On the Mechanism and Prevention of Cavitation. Discussion and Author's Closure. . . . Phillip Eisenberg. *U.S., Navy Dept. David W. Taylor Model Basin, Rep. 842, 842A (NS 715-102)*, June, 1953. 24 pp., 13 pp. 48 refs.

Reference Works

The 1954 Instruments Index. *Instruments*, Aug., 1953, Part II. 212 pp. Alphabetical listings of products and manufacturers of measuring, computational, testing, and automatic control devices.

Special SBAC Issue: Britain's Aircraft Industry. *Flight*, Sept. 4, 1953. 271 pp., cutaway drawings, charts, tables, diagrams. Partial contents: British Aircraft, 1953. Aircraft, Tabulated Data. Tabulated Engine-Data. The Aircraft Industry Directory. Proprietary Equipment.

Rotating Wing Aircraft

Design of the Hiller HJ-1, YH-32 Helicopter. Harvey Holm. *Aero. Eng. Rev.*, Oct., 1953, p. 48. Design development and testing programs.

Flight Measurements and Analysis of Helicopter Normal Load Factors in Maneuvers. F. B. Gustafson and Almer D. Crim. *U.S., NACA TN 2990*, Aug., 1953. 29 pp.

Helicopter Drive Design. Richard M. Carlson. *Mach. Des.*, Aug., 1953, p. 126, cutaway drawing. Application of Hiller model HTE-2 and H-23B components to exacting performance requirements.

Studies of the Lateral-Directional Flying Qualities of a Tandem Helicopter in Forward Flight. Kenneth B. Amer and Robert J. Tapscott. *U.S., NACA TN 2984*, Aug., 1953. 42 pp.

Structures

The Phase-Plane Construction in Problems of Elastic Impact. R. E. D. Bishop. *The Engr.*, Aug. 7, 1953, p. 168. Study of the particular case of propagation of a stress wave in a Hopkinson pressure bar.

A Qualitative Study of Residual Stresses in Welds by Photoelasticity. Melvin Mark. *Welding J. Res. Suppl.*, Aug., 1953, p. 374-s. Methods to reduce high peaks at center and ends of a weld.

Some Information on the Strength of Thick-Skin Wings with Multiweb and Multipost Stabilization. Roger A. Anderson, Richard A. Pride, and Aldie E. Johnson, Jr. *U.S., NACA RM L53F16*, Aug. 27, 1953. 19 pp. Experimental analysis of structural strength characteristics.

The Eaton Process of Producing Jet Blades is Saving Critical Materials—Reducing Costs by Millions of Dollars

The savings inherent in Eaton processes for the production of jet engine blades are an accomplished fact – savings in critical materials, savings in cost totaling millions of dollars. These cost-saving processes have been developed and perfected *in production* – representing millions of blades for jet engines now in active service.

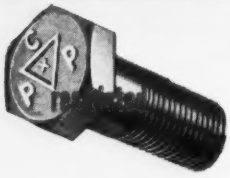
Eaton research – in the laboratory and in the shop – will continue to strive for the achievement of the high quality necessary for these critical parts – at the lowest possible cost!

EATON MANUFACTURING COMPANY

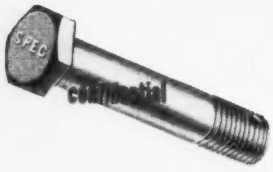
General Offices: CLEVELAND, OHIO

VALVE DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers



close tolerance
AN and NAS standards



high tensile
cold-rolled fillet

special alloy
Monel, Inconel, stainless

special design
for high temperature applications

If it has to be "as good as a Cooper bolt," buy it from

COOPER
precision products

5625 WEST CENTURY BOULEVARD
LOS ANGELES 45, CALIFORNIA

The Statistical Significance of a Few Fatigue Results. G. J. Schott. *Canada, NAE LR 58*, May 26, 1953. 27 pp. Research analysis of the fatigue life of structures.

Structural Efficiencies of Various Aluminum, Titanium, and Steel Alloys at Elevated Temperatures. George J. Heimerl and Philip J. Hughes. *U.S., NACA TN 2975*, July, 1953. 16 pp. Analysis of strength under uniaxial compression, elastic stiffness, column buckling, and the buckling of long plates in compression or in shear.

Testing Structural Panels with Low Pressure Air. *Appl. Hydraulics*, Sept., 1953, p. 66. Pneumatic equipment to determine elastic limit, web crippling point, and failure of panel sections; applications include air-frame and wing testing.

Beams & Columns

Column Strength of H-Sections and Square Tubes in Postbuckling Range of Component Plates. P. P. Bijlaard and G. P. Fisher. *U.S., NACA TN 2994*, Aug., 1953. 106 pp. 19 refs.

Forms of Section for Struts. C. G. Watson. *The Engr.*, July 31, 1953, p. 133. Practical application of experimental data on structural design for strut sections of aluminum alloy Noral 51ST.

The Normal Functions of Beam Vibration in Series Solutions of Static Problems. R. E. D. Bishop. *J. RAeS*, Aug., 1953, p. 527.

The Stability and Strength of Thin-Walled Steel Struts. A. H. Chilver. *The Engr.*, Aug. 7, 1953, p. 180. Analysis of compression strength of steel channel sections.

Unsymmetrical Bending and Bending Combined with Axial Loading of a Beam of Rectangular Cross Section into the Plastic Range. Anthony J. Barrett. *J. RAeS*, Aug., 1953, p. 503. Mathematical stress-strain curve analysis.

Cylinders

Designing Cylinders and Struts for Maximum Strength. B. Saelman. *Mach. Des.*, Aug., 1953, p. 133. Analysis based on practical limitations imposed by machinability requirements and permissible deformation to arrive at the optimum strength-weight ratio.

Détermination de l'État de Contraintes à Partir de Mesures d'Allongements par le Cercle de Mohr et Son Pole. R. Kappus. *La Recherche Aéronautique*, May-June, 1953, p. 47. In French. Graphic determination of the state of cylindrical strain and deformation, beginning with elongation measurements, by a method based on a property of Mohr's circle and its pole.

Plastic Stress-Strain Relations Under Radial and Non-Radial Combined Stress Loading. Joseph Marin and John A. Sauer. *J. Franklin Inst.*, Aug., 1953, p. 119. Experimental analysis using aluminum alloy tubes subjected to internal pressure and axial loads.

Plates

Charts Relating the Compressive Buckling Stress of Longitudinally Supported

A COMPLETE MEDIA PACKAGE

FOR YOUR

Aviation Marketing Program

AERONAUTICAL ENGINEERING REVIEW

For your monthly advertising messages to the aircraft industry's engineering and design personnel—the men who influence buying.

AVIATION MARKET GUIDE Now Available!

24 pages of FACTS on your market and REVIEW.

Write for your free copy TODAY!

AERONAUTICAL ENGINEERING CATALOG

Prefiles and distributes your aircraft products catalog to aviation's buyers and specifiers.

7,000 copies are distributed annually to aircraft engineers, designers, technicians and purchasing agents in all leading aircraft, engine and parts companies, Government aviation departments and leading air lines.

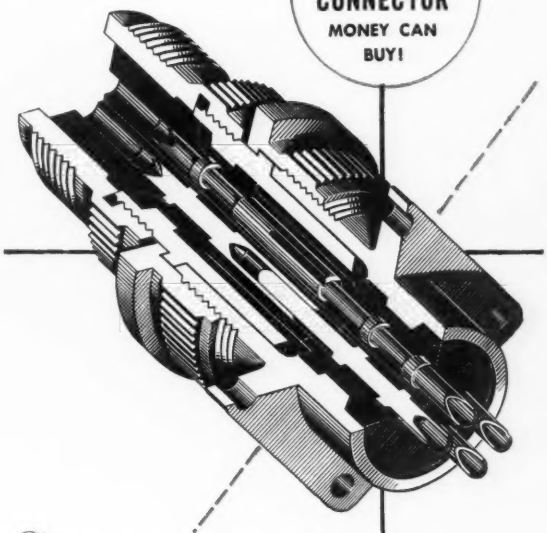
Write for your free copy of 12-page MARKET BOOK giving full details.

OFFICIAL PUBLICATIONS:

INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th Street New York 21, N.Y.

The Finest **ELECTRICAL CONNECTOR MONEY CAN BUY!**



SCINFLEX **ASSURES YOU PEAK PROTECTION AGAINST CIRCUIT FAILURE**

When operating conditions demand an electrical connector that will stand up under the most rugged requirements, always choose Bendix Scinflex Electrical Connectors. The insert material, an exclusive Bendix development, is one of our contributions to the electrical connector industry. The dielectric strength remains well above requirements within the temperature range of −67°F to +275°F. It makes possible a design increasing resistance to flashover and creepage. It withstands maximum conditions of current and voltage without breakdown. But that is only part of the story. It's also the reason why they are vibration-proof and moisture-proof. So, naturally, it pays to specify Bendix Scinflex Connectors and get this extra protection. Our sales department will be glad to furnish complete information on request.

• Moisture-Proof • Radio Quiet • Single Piece Inserts • Vibration-Proof • Light Weight • High Insulation Resistance • High Resistance to Fuels and Oils • Fungus Resistant • Easy Assembly and Disassembly • Fewer Parts than any other Connector • No additional solder required.

BENDIX SCINFLEX

ELECTRICAL CONNECTORS

Bendix

SCINTILLA MAGNETO DIVISION of Bendix AVIATION CORPORATION

SIDNEY, NEW YORK

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

FACTORY BRANCH OFFICES: 117 E. Providencia Ave., Burbank, Calif. • Stephenson Bldg., 6560 Cass Ave., Detroit 2, Michigan • Brouwer Bldg., 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 582 Market Street, San Francisco 4, California.

Plates to the Effective Deflectional and Rotational Stiffness of the Supports. Roger A. Anderson and Joseph W. Semonian. *U.S., NACA TN 2987*, Aug., 1953. 53 pp.

Elastic Plastic Stress Field in Perforated Plate. Yoshio Akita. *Japan Sci. Rev.*, Apr., 1952, p. 361. Analytical method with numerical example.

General Instability of Simply Supported Rectangular Plates. J. R. M. Radok. *Australia, ARL Rep. SM. 204*, Mar., 1953. 21 pp. Solution of the problem by equilibrium and buckling equations.

A Note on the Buckling of Simply Supported Parallelogram Plates. J. Guest and J. P. O. Silberstein. *Australia, ARL S & M Note 204*, May, 1953. 7 pp.

Thermodynamics

Combustion. Bernard Lewis and Guenther von Elbe. *Ind. & Eng. Chem.*, Sept., 1953, p. 1921. 586 refs. Review of the literature covering research on combustion reactions, ignition, propagation, stabilization of combustion waves, simultaneous mixing and combustion of fuel jets, and other problems.

The Design of Tube Plates in Heat Exchangers. K. A. G. Miller. *IME Proc. (B)*, No. 6, 1952, p. 215; Communications, p. 228. Development of design formulas for the maximum stress in both the tube plate and the tubes; includes an algebraic expression to cover weakening effect of holes, with the tube plate treated as a thin circular plate resting on an elastic foundation to account for the support given by the tubes.

Heat Transfer to Molten Lead-Bismuth Eutectic in Turbulent Pipe Flow. H. A. Johnson, J. P. Hartnett, and W. J. Clabaugh. *Trans. ASME*, Aug., 1953, p. 1191. 18 refs.

Preliminary Results of Heat Transfer from a Stationary and Rotating Ellipsoidal Spinner. U. von Glahn. *U.S., NACA RM E53F02*, Aug. 6, 1953. 35 pp. 12 refs. Results given in terms of Nusselt Numbers, Reynold Numbers, and convective heat-transfer coefficients.

The Solution of Transient Heat-Flow Problems by Analogous Electrical Networks. I, II. D. I. Lawson and J. H. McGuire. *The Engr.*, Aug. 14, 21, 1953; pp. 217, 249. Design of a machine for solving heat-conduction problems using a cathode-ray tube; discussion of the representation of cooling by radiation and convection.

The Stability of Gaseous Lithium Hydroxide at High Temperatures and Its Relation with the Hydroxyl Concentration of Flame Gases. H. Smith and T. M. Sugden. *Proc. Royal Soc. (London), Ser. A*, Aug. 25, 1953, p. 204.

Temperatures, Thermal Stress, and Shock in Heat-Generating Plates of Constant Conductivity and of Conductivity That Varies Linearly with Temperature. S. V. Manson. *U.S., NACA TN 2988*, July, 1953. 62 pp.

Water-Borne Aircraft

The High-Speed Planing Characteristics of a Rectangular Flat Plate Over a Wide Range of Trim and Wetted Length. Irving Weinstein and Walter J. Kapryan. *U.S., NACA TN 2981*, July, 1953. 29 pp. 12 refs.

Wind Tunnels & Research Facilities

Aircraft in Research and Development. Howard Beale. *Aircraft* (Australia), July, 1953, p. 50. ARL design studies and other activities; flight tests at the Woomera rocket range.

Airframe Test House and Wind Tunnel. *The Engr.*, July 31, 1953, p. 147. The Handley Page Radlett Aerodrome Laboratory's testing facilities.

The First Air-driven Ultra-Centrifuge in Japan. Shigeo Sasaki and Osamu Taniguti. *Japan Sci. Rev.*, Apr., 1952, p. 327. Design principles and operational analysis of the apparatus; research possibilities.

A Modern Wind Tunnel Balance. L. E. Leavy and C. G. Saunders. *J. RAeS*, Aug., 1953, p. 491. Design, description, and testing of a new six-component balance at the Blackburn and General Aircraft Aerodynamics Lab., Brough, England.

Studies of the Use of Freon-12 As a Wind-Tunnel Testing Medium. Albert E. von Doenhoff, Albert L. Braslow, and Milton A. Schwartzberg. *U.S., NACA TN 3000*, Aug., 1953. 57 pp.

Modern Model Testing. I. W. A. Crago. *Saro Prog.*, Summer, 1953, p. 13. Saunders-Roe Hydrodynamics Dept. water-tank testing.

Visualization en Tunnel Hydrodynamique; Dispositifs Réalisés; Méthodes Utilisées; Resultats Obtenus. H. Werlé. *La Recherche Aéronautique*, May–June, 1953, p. 3. In French. Qualitative analysis of flow visualization studies of a model in a hydrodynamic tunnel.

General Theory and Operational Characteristics of the Gyrotron Angular Rate Tachometer

(*Concluded from page 36*)

Much of the development work conducted thus far at Sperry Gyroscope Company has been directed toward determining basic characteristics and resolving advantages and limitations with application requirements.

The inherent features of the Gyrotron angular rate tachometer are summarized below. The importance of each will depend upon application requirements.

(1) *Unique Sensitivity.*—The Gyrotron angular tachometer is sensitive only to angular velocity about a single input axis.

(2) *Negligible Acceleration Errors.*—Acceleration about or along any axis will not be measured as a false input velocity.

(3) *Wide Range of Rate Measurements.*—Angular rate measurements over a range of one million to one can be provided with good linearity.

(4) *Rapid Response.*—A response in the order of 0.005 sec. and lower can be achieved readily.

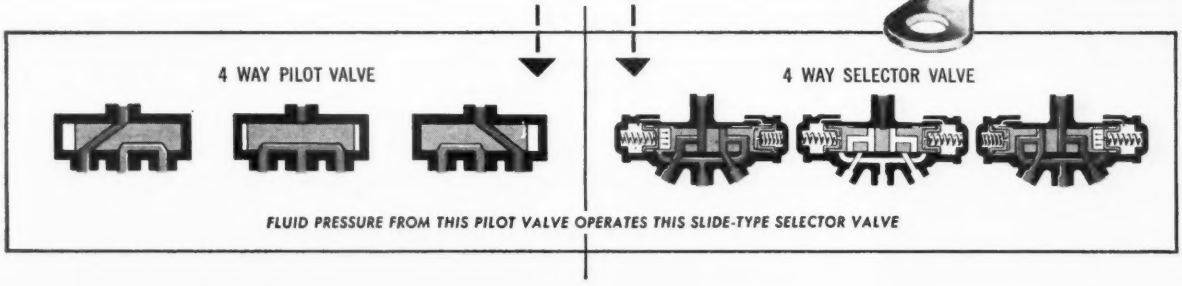
(5) *Long Life Expectancy.*—There are no bearings in this device and few moving parts. No adjustments to the sensitive element are required, consequently there is no maintenance problem.

(6) *Ruggedness.*—Because of its inherently sturdy construction, the instrument will withstand vibration and shock encountered in the most grueling applications.

smaller..

lighter..

. . . and it does not leak



General Controls

AV-14

hi-g electro-hydraulic selector valves

General Controls AV-14 Series electrohydraulic selector valves guarantee positive control of high-pressure and high flow hydraulic systems. The pilot valve, balanced by opposing continuous duty solenoids, positions the selector valve by directing fluid to one end of the slide and returning it at the other. This double balance permits maximum efficient control with minimum current drain. Compact and light weight, with specially hardened and optically ground sealing surfaces that approach "zero" leakage. General Controls Hi-g selector valves provide leakproof control of all fluids at pressures ranging from 150 to 3000 psi. For complete information on the AV-14 Series, the AV-16 Gate Valve Series and Hi-g Limit Controls, send for your copy of Catalog 53A today.

GENERAL CONTROLS

Glendale, California • Skokie, Illinois

Manufacturers of Automatic Pressure, Temperature, Level and Flow Controls for Heating, Home Appliances, Refrigeration, Industrial and Aircraft Applications.

FACTORY BRANCHES IN 35 PRINCIPAL CITIES

See your classified telephone directory.

NAME IT...
and you can have it!

Need any part or all of a pneumatic system? Just name it and chances are we can supply it.

If you're still in the planning stage, be sure to call on our engineering department. Put their years of experience to work for you. It can probably save you time and money.

The nameplates before you are from only a few of the pneumatics parts rolling off the Kidde production line. Kidde pneumatic components are now being used on almost every make and type of plane.* Their basic designs are easily adjusted to just about any pneumatic need.

Write today for full information.

*F2Y1, B29, B36, B47, B50, B52, B57, DC4, DC6, DC7, C124, C119, Convair 340, C123, F94, F7U3, F4U7, AU1, F3D, F9F, AD4, P2V, P4M, P5M, F2H, F3H, F101, F100, FJ2, F89.

Kidde

Walter Kidde & Company, Inc.
1111 Main Street, Belleville 9, N. J.
Walter Kidde & Company of Canada, Ltd., Montreal, P. Q.

Aeronautical Reviews — BOOKS

Book Notes

AIR TRANSPORTATION

Report on Civil Aviation in Australia and New Guinea, 1950–1952. Melbourne, Australia, Department of Civil Aviation, 1953. 116 pp., illus.

A detailed summary of activities concerned with personnel and establishments, finance, air transport, airports, airways, air navigation and accidents. The latter half of the book is devoted to statistical data.

BIOGRAPHY

Bicycle in the Sky. Rose Brown. Illustrated by Ann Sayre Wiseman. New York, Charles Scribner's Sons, 1953. 183 pp., illus. $2.50.

The story of Alberto Santos-Dumont written in narrative fashion for younger readers.

ELECTRONICS & ELECTRICITY

Television and Radar Encyclopaedia. Edited by W. MacLanachan. New York, Pitman Publishing Corporation, 1953. 216 pp., illus., diagrs. $6.00.

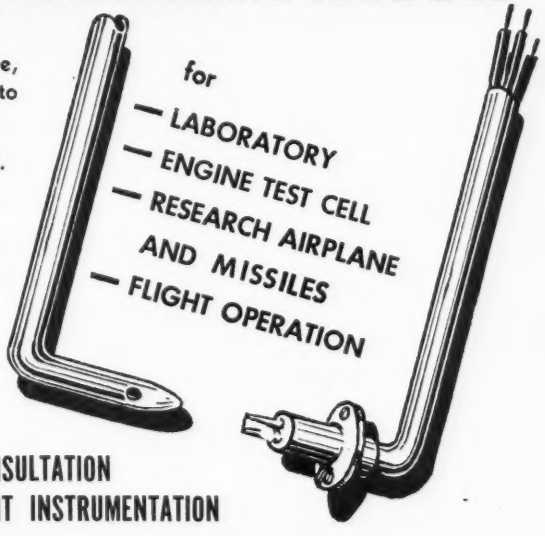
This volume is a reference book of television and radar terms that are or are likely to be in common use in Great Britain and the United States. The information as given is technical, but it is given in simple language. Although no design information or detailed formulas are included, it is suitable as a reference book for engineers. Throughout the work, under the more important headings, are informative articles contributed by leading authorities in their respective fields. The book is well illustrated with over 200 photographs and diagrams.

Circuit Theory of Electron Devices. E. Milton Boone. New York, John Wiley & Sons, Inc., 1953. 483 pp., illus. $8.50.

The material included in this book has been used by The Ohio State University during the last half of the third and the first quarter of the fourth year of the electrical engineering curriculum. Course prerequisites include mathematics through differential and integral calculus, one year of physics at the sophomore level, and one year of work in the circuit theory including some treatment of differential equations, transients and Fourier series. The utilization of the concepts of four-terminal networks is sufficiently general as to apply to any electron device over any frequency range in which the device operates within the linear region of its characteristics. Diodes, triodes, and equivalent circuits are discussed in

FLUID FLOW INSTRUMENTATION

- Designing and fabricating thermocouples, pressure, velocity, direction and hot wire anemometer probes to solve your flow measuring problems.
- Accurately fabricating probes to your specific designs.
- Aerodynamic calibrations for all probes we supply.
- Designing complete temperature and pressure measuring systems for your test rigs.
- Production facilities for manufacturing large quantities of thermocouple probes for the operational engine.



DESIGN, SPECIAL FABRICATION, PRODUCTION, CONSULTATION
for TURBO JET—RAM JET—ROCKET—COMPONENT INSTRUMENTATION

AERO RESEARCH INSTRUMENT COMPANY

Our engineering staff is familiar with problems in fluid flow measurement. For further information write to

1903 NORTH HERMITAGE AVENUE • CHICAGO 22, ILLINOIS

SUB-MINIATURE
PILOT LIGHTS
Approved for AIRCRAFT
AND IMPROVED IN IMPORTANT DETAILS

DIALCO

SUB-MINIATURE INDICATOR ASSEMBLIES

A great aid to your miniaturization program

MOUNT IN 15/32" HOLE
ALL LENS COLORS

Easy lamp replacement with any midget flanged base lamp types

Complete blackout or semi-blackout dimmer types

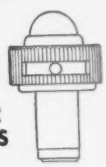
NON-DIMMING
No. 8-1930-621

MECHANICAL DIMMER
No. 11-1930-621

THESE ASSEMBLIES LOGICALLY REPLACE LAMPS NO. 319, 320, and 321

REPLACE WITH THIS

NOT THIS

OR THIS 

PLASTIC PLATE (EDGE) LIGHT ASSEMBLIES

AIR FORCE and BUREAU of AERONAUTICS
MIL-L-7806 DRAWING MS-25010

DIALCO *No. TT-51* (Red filter-black top)
. . . or, *No. TT-51A*, complete with No. 327 Lamp

ALSO MADE
with other filter colors
and with *light-emitting top* (for indication)

ALL OF THE ASSEMBLIES ILLUSTRATED ACCOMMODATE LAMPS NOS. 327, 328, 330, and 331.

ANY ASSEMBLY AVAILABLE COMPLETE WITH LAMP

SAMPLES ON REQUEST—NO CHARGE

Foremost Manufacturer of Pilot Lights
DIALIGHT CORPORATION
60 STEWART AVENUE, BROOKLYN 37, N. Y. HYACINTH 7-7600

the opening chapter. Chapter 2 is concerned with tetrodes, pentodes, and equivalent circuits. In Chapters 3 and 4 a.f. voltage amplifiers and power stage are treated. Chapter 5 covers gas-filled tubes, while Chapters 6 and 7 discuss the characteristics of single-phase rectifiers and power supplies, and polyphase rectifiers. Tuned radio-frequency and band-pass amplifiers are analyzed in Chapter 8; radio-frequency power amplifiers in Chapter 9. The final three chapters deal with vacuum-tube oscillators, modulation and demodulation, and the circuit theory of transistors.

Electric Circuit Theory and the Operational Calculus. John R. Carson. 2nd Ed. New York, Chelsea Publishing Company, 1953. 197 pp., illus. $3.95.

Soft Magnetic Materials Used in Industry. A. E. De Barr. (Monographs for Students.) London, The Institute of Physics, 1953. 62 pp., illus. 5*s*.

Contents: List of Principal Symbols. (1) Introductory. (2) The Domain Theory of Ferromagnetism. (3) The Properties of Commercial Magnetic Materials. (4) Silicon-Iron Alloys. (5) Nickel-Iron Alloys. (6) Applications of Soft Magnetic Materials. Bibliography. Index.

The Magnetic Circuit; Powder Cores, Ferrites, Permanent Magnet Materials and Miscellaneous Magnetic Materials. A. E. De Barr. (Monographs for Students.) London, The Institute of Physics, 1953. 62 pp., illus. 5*s*.

American Electricians' Handbook. Terrell Croft. Revised by Clifford C. Carr. 7th Ed. New York, McGraw-Hill Book Company, Inc., 1953. 1773 pp., illus., diagrs. $10.

The seventh edition of this standard reference book for practical electrical workers has been fully revised in accordance with the 1951 National Electrical Code. Its topics range from fundamentals of electricity to practical suggestions for remedying the troubles of electrical equipment. It includes data and guidance for the selection, installation, operation, care, and proper application of electrical apparatus and materials.

FLIGHT SAFETY

Survey of Research Projects in the Field of Aviation Safety. Second Annual Supplement, January, 1953. New York, The Daniel &, Florence Guggenheim Aviation Safety Center at Cornell University, 1953. 109 pp. $1.00.

This report is the third in a series of annual "Survey of Research Projects in the Field of Aviation Safety." The first report in 1951 adopted the pattern of listing research projects under various headings, consolidating information on nonclassified research conducted in various fields affecting aviation safety. The current report not only contains several hundred projects not formerly listed, but, in its preparation, the status of all previous projects was checked and the descriptive statements revised in accord with information obtained. The section on "Completed Projects" has been enlarged; and, in order to obtain the full record of any particular subject, the completed project list should be examined.

ICING

Occurrence of High Rates of Ice Accretion on Aircraft. A. C. Best. (Gt. Brit., Air Ministry M.O. 524 f; Professional Notes No. 106.) London, H.M. Stationery Office; New York, British Information Services, 1952. 22 pp., figs. $2.00.

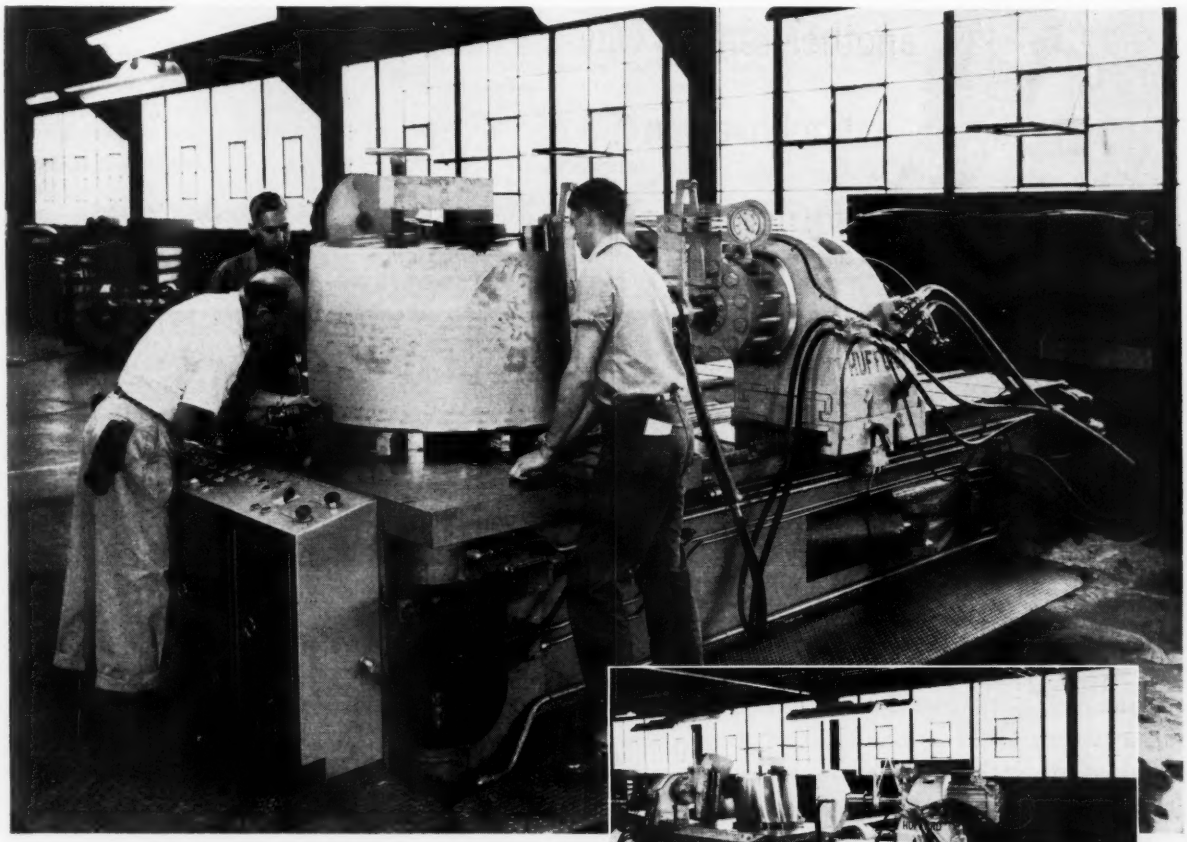
INSTRUMENTS

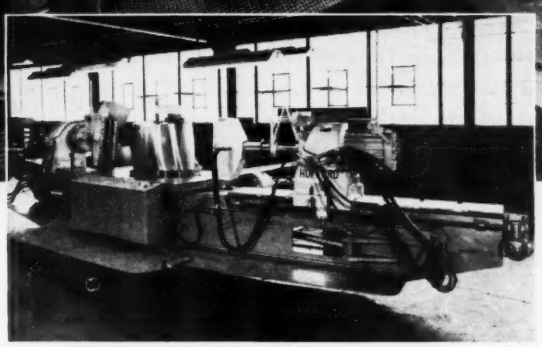
Fundamentals of Thermometry. J. A. Hall. (Monographs for Students.) London, The Institute of Physics, 1953. 48 pp., illus. 5*s*.

Contents: (1) The Temperature Scale. (2) The Standard Platinum Resistance Thermometer. (3) The Standard Thermocouple. (4) The Standard Optical Pyrometer. (5) The Mercury-in-Glass Thermometer. (6) Realization of the International Temperature Scale. Bibliography. Index.

Simple Model A-12 Conversion

Does the work of TWO Machines!





Raising blocks under tension cylinders accommodate 30" sheet jaws; increase sheet width capacity 50%. Machine still retains original efficiency on small extrusion forming.

1. Stretch-wrap forms *all small extrusions!*
2. Handles sheet widths *up to 30"!*
3. Saves an *extra* machine installation!

Arnolt Corporation, Indianapolis Division, was faced with a puzzling problem: how to handle their wide range of subcontract forming on a single, between-size machine. Tooling—already developed for another type press—had to be utilized without alteration.

This Hufford Model A-12 conversion did the trick, covering an unusually wide scope of operations. Sheet capacity has been increased 50%—from 20" to 30" widths—by special raising blocks beneath tension cylinder brackets. At the same time, the machine still handles all small extrusion forming jobs normally put on a Model A-10. The conversion is rated at 50 tons capacity and is successfully doing jobs usually requiring both a larger and smaller machine. The user reports complete satisfaction with this A-12 modification, turning out excellent production with better-than-ever quality.

Perhaps one of the many Hufford machines or a similar adaptation to the above will help solve your forming problems. We'll be glad to make suggestions.

HUFFORD
Machine Works Inc.
EL SEGUNDO, CALIFORNIA

Manufacturers of

PRECISION HYDRAULIC 5 HOUR FORMING PRESSES
PORTABLE HYDRAULIC ELEVATORS • HYDRAULIC STRETCH-LEVELING TABLES
HYDRAULIC STRETCH-WRAP FORMING MACHINES
HYDRAULIC METAL FORMING BULLDOZERS • HYDRAULIC COMPACTION PRESSES
CUSTOM-MADE HYDRAULIC MACHINE TOOLS AND ACCESSORIES

diversification:

another reason why

Lockheed in

California offers...

better careers for engineers

diversified production

Huge luxury airliners, cargo transports, fighters, bombers, trainers and radar search planes are rolling off Lockheed assembly lines. Twelve models are in production.

diversified development projects

The most diversified development program in Lockheed's history is under way—and it is still growing. The many types of aircraft now in development indicate Lockheed's production in the future will be as varied as it is today—and has been in the past.

diversified living

You work better in Lockheed's atmosphere of vigorous, progressive thinking—and you live better in Southern California. You enjoy life to the full in a climate beyond compare, in an area abounding in recreational opportunities for you and your family.

This capacity to develop and produce such a wide range of aircraft is important to career-conscious engineers. It means Lockheed offers you broader scope for your ability. It means there is more opportunity for promotion with so many development and production projects constantly in motion. It means your future is not chained to any particular type of aircraft—because Lockheed is known for leadership in virtually all types of aircraft. Lockheed's versatility in development and production is also one of the reasons it has an unequaled record of production stability year after year.

result of diversification:
new career positions
at Lockheed are listed at right

Lockheed AIRCRAFT CORPORATION

BURBANK, CALIFORNIA

Lockheed's program of diversified expansion has created openings for:

aerodynamics engineers
aerodynamicists "A"
aerodynamicists "B"
jr. engineers (for aerodynamics work)
a college degree in aeronautical engineering or a mechanical engineering degree with an aero option.

thermodynamics engineers
thermodynamicists "A"
thermodynamicists "B"
jr. engineers (for thermodynamics work)
a college degree in aeronautical engineering or a mechanical engineering degree with a thermo, aero or power plant option.

in addition, Lockheed's diversified expansion program has created immediate openings for:
service manuals engineers
flight test engineers

---

design engineer "A"
nine years' training and experience including four years' university engineering training and five years' experience in drafting and designing work on aircraft or in closely allied fields.

design engineer "B"
seven years' training and experience including four years' university engineering training and three years' layout drafting or shop liaison in aircraft or closely allied fields.

jr. engineer — draftsmen "A"
five and one-half years' training and experience including four years' university engineering training and 18 months' detail or layout drafting on aircraft or related fields.

jr. engineer — draftsmen "B"
an engineering degree from a recognized school of engineering. Experience is not required of recent engineering graduates.

Lockheed invites qualified engineers to apply for these positions. Coupon below is for your convenience.

Mr. E. W. Des Lauriers,
Engineering Recruiting, Dept. AER-11
Lockheed AIRCRAFT CORPORATION
Burbank, California

Dear Sir: Please send me an application form and illustrated brochure describing life and work at Lockheed in California.

my name

my field of engineering

my street address

my city and state

REPRINTED BY COURTESY OF CALIFORNIA INSTITUTE OF TECHNOLOGY, BUFFALO PUBLIC LIBRARY

Practical Thermometry. J. A. Hall. (Monographs for Students.) London, The Institute of Physics, 1953. 51 pp., illus. 5*s*.

Contents: (1) Electrical Resistance Thermometers. (2) Thermocouples. (3) Expansion Thermometers. (4) Optical and Radiation Pyrometers. (5) The Calibration of Instruments. (6) Temperature Measurement in Practice. Bibliography. Index.

LAW

Derecho Aeronáutico de Guerra; Introducción y Elementos. (The Law of Air Warfare; Introduction and Fundamentals.) Ricardo A. Foglia. (Círculo de Aeronáutica, Vol. 28.) Buenos Aires, Colección Aeronáutica Argentina, Republica Argentina, 1952. 175 pp. (In Spanish.)

MATERIALS

Weldability of Steels. Robert D. Stout and W. D'Orville Doty. New York, Welding Research Council, 1953. 381 pp., figs. $6.50.

The early chapters of this monograph cover briefly the fundamentals of welding processes and metallurgy in relation to weldability. Next comes consideration of the basic factors that influence the weldability of carbon and low-alloy steels, after which are presented suggested methods for welding commonly used steels. The remaining chapters contain a review and critical evaluation of weldability tests and general conclusions on existing knowledge of weldability. This volume is based to a large extent on research work sponsored over the past decade by the Weldability Committee of the Welding Research Council. Many of the investigations were financed by the American Iron and Steel Institute. Following a list of 200 references, the book concludes with an appendix that presents suggested procedures for welding and tables of steels meeting standard specifications. Dr. Stout is Professor of Metallurgy, Lehigh University, and Dr. Doty is Welding Metallurgist, United States Steel Corporation.

Welding Aluminum. Louisville, Ky., Reynolds Metals Company, 1953. 185 pp., illus., diagrs. $1.00.

This new edition contains material on 34 processes suitable for welding, brazing, and soldering aluminum and its alloys. Among the processes described are flow, stud, induction, and cold welding. Induction brazing and resistance brazing are described in addition to the more widely known methods. The concluding chapters deal with soldering aluminum, weld inspection for government requirements, jointing aluminized steel, and localized annealing. An index of tables and an itemized cross index of topics are provided.

MATHEMATICS

Higher Transcendental Functions. Based, in Part, on Notes Left by Harry Bateman, Late Professor of Mathematics, Theoretical Physics, and Aeronautics at the California Institute of Technology, and Compiled by the Staff of the Bateman Manuscript Project. New York, McGraw-Hill Book Company, Inc., 1953. 302 pp., illus. $6.50.

The present volume is the first of three projected volumes on the higher transcendental functions. These three volumes are to be followed by two volumes of integral tables. In this volume are included most of the important functions that occur in applied mathematics. Both the choice of the functions to be included and the choice of the notation were made on mathematical grounds. Special functions that had not been investigated mathematically were excluded, even though they had been tabulated or otherwise made useful in applications. On the other hand, there have been included special functions not usually found in a work of this kind—for instance, functions occurring in number theory, and special automorphic functions. Each chapter is accompanied by a list of references designed not only to document the material presented in that chapter but also to assist the reader in finding further information. The degree of completeness of these

AVICA
HOT AIR LINES
UP TO 700° FAHR.

AVICA Stainless Steel flexible Tube Assemblies carry HOT AIR at 700° Fahr. plus and are

FIRE RESISTANT

Fire resistant hot air lines are recommended because they will not fail under flame attack and render ineffective the fire extinguisher system by spilling a large volume of high pressure air into the engine nacelle. 100% reliability is ensured during the critical period before final fire extinguishment.

AVICA is always ready to discuss special applications with customers and to develop tube assemblies to deal with unusual operating conditions.

WRITE TO SPECIAL PROJECTS DEPT. A. E. FOR FURTHER INFORMATION

AVICA CORPORATION
P. O. BOX 1090
PORTSMOUTH, RHODE ISLAND
TEL. PORTSMOUTH 479

lists varies with the individual tests of the authors and with the importance and nature of the functions.

Contents: Chapter 1, The Gamma Function. Chapter 2, The Hypergeometric Function; First Part: Theory; Second Part: Formulas. Chapter 3, Legendre Functions. Chapter 4, The Generalized Hypergeometric Series. Chapter 5, Further Generalizations of the Hypergeometric Function; Macrobert's *E*-Function, Meijer's *G*-Function, Hypergeometric Functions of Several Variables. Chapter 6, The Confluent Hypergeometric Function. Subject Index and Index of Notations.

Projective Geometry and Projective Metrics. Herbert Busemann and Paul J. Kelly. New York, Academic Press Inc., 1953. 332 pp., illus. $6.00.

The present book represents an effort to emphasize the fact that the basic results, and even more the methods, of projective and non-Euclidean geometry are as indispensable for the geometer as calculus is for the analyst. Special results are discussed in greater number only when they are needed to develop a feeling for the subject or when they illustrate a general method. Considerable space is devoted to the discussion of the basic concepts of distance, motion, area, and perpendicularity. The first five chapters of the book have been planned as a year course. From the outset, a knowledge of the theory of equations is presupposed along with elementary matrix theory. The last chapter has been written for the more mature student who has mastered the earlier material. Instead of explicit exercises, the proofs of many theorems, and most of the generalizations from two to three dimensions, are left to his initiative.

Contents: Chapter 1, The Projective Plane. Chapter 2, Polarities and Conic Sections. Chapter 3, Affine Geometry. Chapter 4, Projective Metrics. Chapter 5, Non-Euclidean Geometry. Chapter 6, Spatial Geometry. Bibliography. Index.

British Standard Presentation of Numerical Values. (B.S. 1957:1953.) London, British Standards Institution, 1953. 15 pp. 3*s*.

METEOROLOGY

The Visual Range in Daylight, Darkness, and Twilight. Maurice A. Garbell. (Garbell Aeronautical Series No. 6.) San Francisco, Garbell Research Foundation, 1952. 38 pp., diagrs. $1.25.

The author discusses and analyzes reasons for critical reduction of the slant visual range during periods of twilight and in the presence of dazzle. He also provides formulas, references, and charts necessary for calculations of visual range in daylight, darkness, and twilight for any given combination of optical extinction coefficients and brightness conditions. Recommended are brief, simple, practical methods of providing pilots with representative reports of actual final-approach weather prevailing along the instrument-approach path.

PERFORMANCE

The Initial En-Route Climb of Aircraft. Maurice A. Garbell. (Aeronautical Series No. 5.) San Francisco, Garbell Research Foundation, 1952. 25 pp., diagrs. $1.00.

The reasons for the dangerous and disturbing losses in altitude are analyzed, an accurate method for calculation, applicable to all types of aircraft, is provided, and a numerical example (DC-6) is offered. Calculations shown are supported by observations in actual scheduled commercial operations. The problem of noise is discussed. Recommendations are advanced for aircraft designers, manufacturers, operators, and pilots.

PHOTOGRAPHY

Physical Aspects of Air Photography. G. C. Brock. New York, Longmans, Green and Co., Inc., 1952. 297 pp., figs., illus. $11.

The aim of this book is to improve the quality of air photographs by interesting air photographers in the physical aspects of their technique. The fifteen chapters of the book are written around a unifying theme—the need for the best resolution of ground detail in every photograph. The relevant properties of the photographic emulsion and problems of exposure and development are treated from the air photographer's point of view. Photographic resolving-power and factors that influence it are given special attention, in both negative and printing stages. Vibration, and other movements that affect image sharpness are discussed, and the effects of atmospheric haze on contrast and tone-reproduction are explained. The author shows that infrared, popularly supposed to be used for haze-penetration and camouflage detection, has little value for these purposes, though useful in other ways, and he also deals with the limited application of color photography. The book is illustrated with reproductions from air photographs, and many of the plates show comparative experiments that disprove common fallacies. Reports on developments during and since World War II in the physical aspects of air photography, which are scattered in the literature, have been brought together by the author, who is associated with the Royal Aircraft Establishment.

PHYSICS

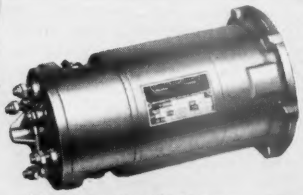
Wave Propagation in Periodic Structures; Electric Filters and Crystal Lattices. L. Brillouin. 2nd Ed. New York, Dover Publications, Inc., 1953. 255 pp., illus. Paperbound student's edition. $1.75.

POWER PLANTS

Die Gasturbine. J. Kruschik. Vienna, Springer-Verlag, 1952. 469 pp., illus., diagrs., figs. $15. (In German.)

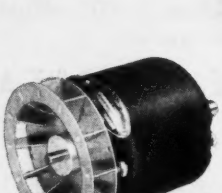
A comprehensive summary and analysis of present knowledge of the theory, design, and application of gas turbines for stationary installations and for marine, locomotive, automotive, and aircraft propulsion. The author, who is associated with Rich. Klinger AG in Austria, begins his book with two chapters devoted to the history of gas-turbine development and general considerations on the basic gas-turbine processes. Chapter 3, a review of the thermodynamics of the gas-turbine, is followed by a section explaining the use of the nine air, gas, and performance tables that are presented in the Appendix. Chapter 4 analyzes the construction of compres-

An Idea to Reduce Costs... Improve Product Operation



Where intermittent high torque and space economy are important, this specially developed aircraft motor provides distinct advantages.

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS



Compactly designed capacitor-type induction motor for wire recorders, electronic tube cooling, and similar services.

• Every Lamb Electric Motor is specially designed for the product or device it is to drive. This means that both mechanical and electrical characteristics are engineered for the exact requirements of the particular application.

Special engineering in Lamb Electric Motors often results in savings in space, weight and cost factor and assures optimum product operation. These are some of the reasons why more and more of America's finest products are being powered with Lamb Electric Motors.

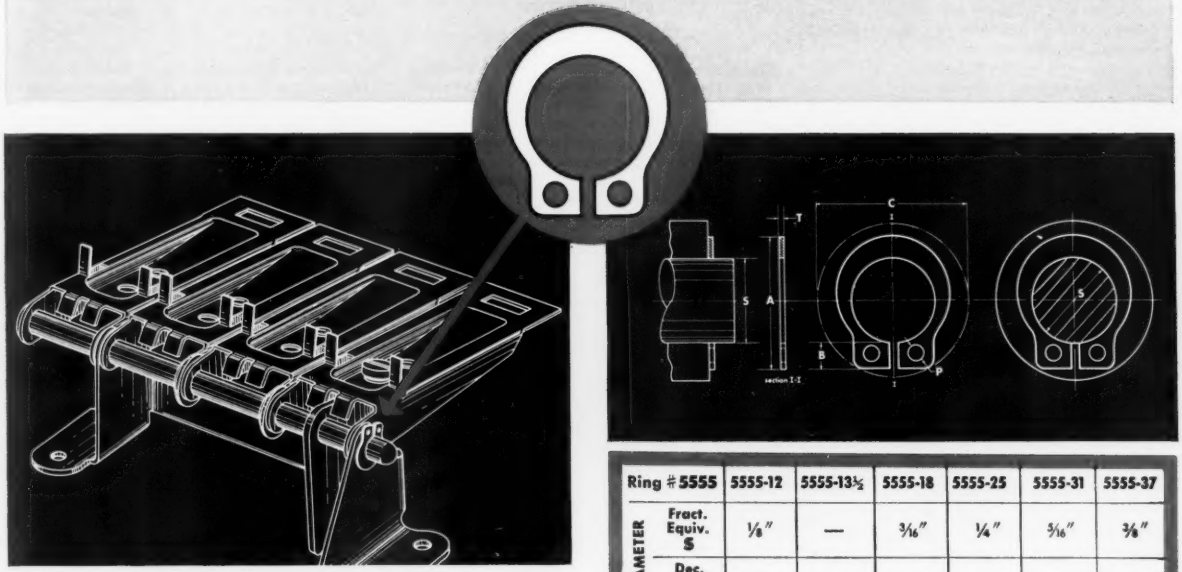
The Lamb Electric Company
Kent, Ohio

In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ont.

THEY'RE POWERING AMERICA'S *Finest* PRODUCTS

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

New Waldes Truarc GRIP Ring requires no groove, holds fast by friction, can be used over and over again



Ring #5555		5555-12	5555-13½	5555-18	5555-25	5555-31	5555-37
SHAFT DIAMETER	Fract. Equiv. S	1/8"	—	3/16"	1/4"	5/16"	3/8"
	Dec. Equiv. S	.125	.136	.187	.250	.312	.375
	TOL.	±.002	±.002	±.002	±.002	±.003	±.003
RING DIMENSIONS	Thickness T	.025	.025	.035	.035	.042	.042
	TOL.	±.0015	±.0015	±.002	±.002	±.002	±.002
	Length A	.268	.285	.364	.437	.553	.626
	Lug B	.078	.078	.097	.097	.141	.141
	Hole P	.042	.042	.042	.042	.078	.078
	Min. Ring Clear C	.33	.34	.44	.50	.67	.73
Approx. Ultim. Thrust Load (Lbs)		20	20	25	35	50	60

The Waldes Truarc Grip Ring is a new, low cost fastener that provides a positioning shoulder secure against moderate thrusts or vibration. Installed on a straight ungrooved shaft, the Truarc Grip Ring can be assembled and disassembled in either direction with Truarc pliers.

The Grip Ring can be installed tightly against a machine part in order to take up end-play. The basic Truarc design principle assuring complete circularity around periphery of the shaft and the ring's unusually large radial width combine to exert considerable frictional hold against axial displacement. The ring can be used again and again.

Find out what Waldes Truarc Retaining Rings can do for you. Send us your drawings. Waldes Truarc engineers will give your problems individual attention without obligation.

SEND FOR NEW CATALOG

WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,948; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,509,081 AND OTHER PATENTS PENDING.

Waldes Kohinoor, Inc., AE-115
47-16 Austel Place, L.I.C. 1, N. Y.

☐ Please send me sample Grip-Rings (please specify shaft size _____)

☐ Please send me the complete Waldes Truarc catalog.

(PLEASE PRINT)

Name _____

Title _____

Company _____

Business Address _____

City _____ Zone ____ State _____

DEPARTMENT OF TECHNOLOGY BUFFALO PUBLIC LIBRARY

sors, turbines, heat exchangers, combustion chambers, fuel delivery and control systems, and fuels. In Chapter 6 are analyzed the performance and operating characteristics of the turbine and its components. The closed cycle and semiclosed cycles form the subjects of Chapters 8 and 9. The remaining four chapters, which comprise 150 pages, contain descriptions and performance analyses of actual power plants. Discussed in detail are gas turbines for industry and metallurgical plants; electric current generation; marine propulsion, locomotives, motor vehicles; and aircraft, both turbojet and turboprop. Useful reference features are a bibliography of 154 references, and a name and subject index.

Gas Turbine Analysis and Practice. Burgess H. Jennings and Willard L. Rogers. New York, McGraw-Hill Book Company, Inc., 1953. 487 pp., illus. $8.50.

This text on gas turbines was prepared by the authors to meet the need for a book presenting a broad, but not detailed, coverage of the operating characteristics, industrial scope, and position that the gas turbine now holds and will attain in the coming years. It is assumed that the readers have some knowledge of basic thermodynamics and mechanics. The material presented deals specifically with the types of problems associated with gas compression and gas-turbine operations. For these applications, the required basic considerations are given in some detail. The set of tables on air properties is included for convenience in solving problems. This volume is directed primarily for undergraduate and graduate engineering students, but is also intended to enable the reader with a good engineering background to orient himself in fundamentals, performance, and practices of the gas turbine. In discussing the field of aircraft propulsion, the authors have given coverage of the characteristics of the reciprocating internal-combustion engine as well as the gas turbine so that each type unit could be placed in its proper perspective as a propulsion drive. Thermodynamic and flow-theory approaches to fundamental design and layout objectives are used. Although aerodynamic aspects of blading in compressors and turbines are discussed, they are not emphasized. Problems for solution by the student and a bibliography of reference material are included in each chapter. The authors are, respectively, Professor and Chairman, Department of Mechanical Engineering, and Assistant Professor of Mechanical Engineering, The Technological Institute, Northwestern University.

For Information on IAS Library Service Facilities, see page 71

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Contents: (1) Development of the Internal-Combustion Engine and Turbine. (2) Thermodynamics and Air Properties. (3) Gas-Turbine Cycles and Thermodynamic Analyses. (4) Gas Turbine Types and Design Features. (5) Axial-Flow Compressors. (6) Centrifugal and Displacement Compressors. (7) Aircraft Propulsion and Jet Engines. (8) Power Plant and Transportation Turbine Units. (9) Fuels, Combustion and Combustion Chambers. (10) Stresses in Turbine-Plant Elements. (11) Vibration and Balancing. (12) Materials and Metallurgy.

PRODUCTION

Engineering Drawing. Frank Zozzora. New York, McGraw-Hill Book Company, Inc., 1953. 369 pp., illus., figs. $5.00.

A text presenting the fundamentals of engineering drawing for teachers, students, and practicing engineers. Accepted practices indicated by the ASA, SAE, company drafting manuals, and similar sources have been referred to in preparing the text, illustrations, and tables. In addition to reading lists on special types of drafting and advanced topics, there is a list of motion pictures and filmstrips on the subject.

RESEARCH

Annual Report, 1951-1952, of the Aeronautical Research Laboratories of the Department of Supply. Melbourne, Australia, 1953. 31 pp., illus.

In addition to summaries of research accomplished during the year, there has been included a list of publications issued by the A.R.L. and of papers published externally during 1950 and 1951.

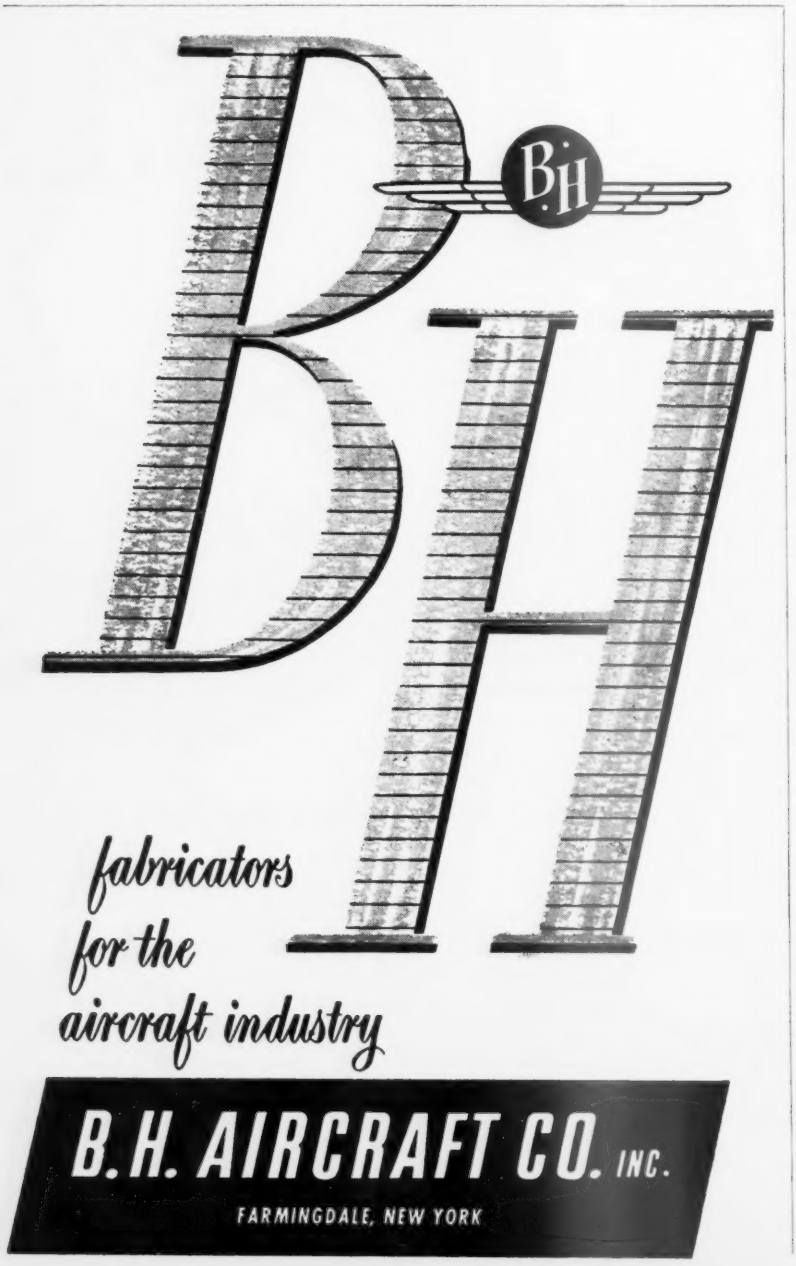
SPACE TRAVEL

The Green and Red Planet; A Physiological Study of the Possibility of Life on Mars. Hubertus Strughold, With Editorial Assistance by Green Peyton. Albuquerque, The University of Mexico Press, 1953. 107 pp., illus., diagrs. $4.00.

YEARBOOKS

Jahrbuch 1952 der Wissenschaftlichen Gesellschaft für Luftfahrt e.V. (WGL). Mit den Vorträgen der Luftfahrtwissenschaftlichen Tagung in Braunschweig vom 21. bis 23. April, 1952. Herausgegeben von Hermann Blenk. Braunschweig, Friedr. Vieweg & Sohn, 1953. 148 pp., illus., diagrs., figs. (In German.)

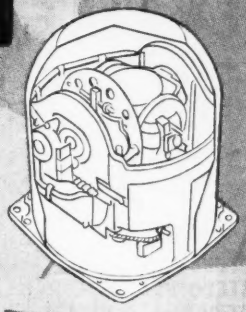
The papers presented at the Brunswick Conference in April, 1952, constitute the main part of the book. The remainder is devoted to a history of the WGL (which regards itself as the legitimate successor of the old WGL, 1912-1936, and of the Lilienthal-Gesellschaft für Luftfahrtforschung 1936-1945); a summary of the April, 1952, Conference; lists of members and special contributors; and the constitution of the organization.



pushing precision toward perfection

Eclipse-Pioneer's "Polar Path" system guided the first commercial over-the-Pole flight* with such accuracy that the log of the now-famous Scandinavian Airlines System's flight carried the notation "works to a miracle". How was it possible to produce this gyro that actually proved to have less than 1° random drift? Admittedly, it was a special gyro, but the answer nevertheless lies in advanced production techniques and facilities that are pushing gyroscope precision toward perfection. Today, *even machining* of gyro parts is being accomplished at E-P in a specially constructed, atmosphere-controlled room where castings "soak" for 36 hours to assure stability of carefully machined tolerances—where electronic air cleaners snatch up foreign particles so fatal to delicate mechanisms—where specially constructed machines automatically hold split-hair tolerances as a matter of routine and surface finishes are maintained to the incredible limits of the thickness of a single light band. In the entire industry, only Eclipse-Pioneer can offer precision mass-production facilities like these—facilities that literally are pushing gyro precision toward perfection.

*NOVEMBER 20, 1952



PRECISION PRODUCTS* MADE BY ECLIPSE-PIONEER

- Automatic Pilot and Flight Path Control Equipment
- Airplane and Engine Instruments
- Flight and Navigation Instruments
- Power Supply Equipment
- Air Pressurization and Ice Elimination Equipment
- Engine Starting Equipment
- Oxygen Equipment
- Precision Components for Servo-mechanism and Computing Equipment
- Sand, Permanent Mold and Die Castings of Magnesium and Aluminum
- Plaster Mold Castings

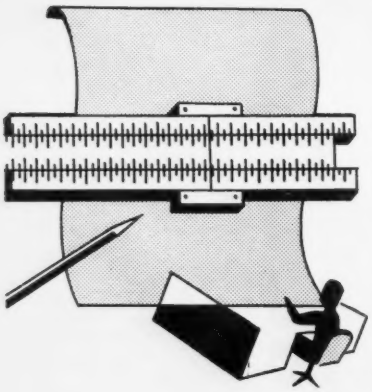
*Manufacturing capacity is now available for a great many models of these products.

Eclipse-Pioneer

TETERBORO, NEW JERSEY · DIVISION OF Bendix AVIATION CORPORATION

Export Sales: Bendix International Division
72 Fifth Avenue, New York 11, N. Y.

World's Largest Producer of Aviation Instruments and Accessories



STRUCTURES ENGINEERS

OPPORTUNITIES AVAILABLE

NOW

FOR

STRUCTURES PROJECT ENGINEER
STRUCTURES RESEARCH ENGINEER
STRUCTURES DESIGN ENGINEERS
STRUCTURES DESIGN ANALYSTS

If you have experience in aircraft structural design, analysis or research . . . . . Challenging Assignments Await You

ON

SUPERSONIC AIRCRAFT

(Airplanes and Missiles)

BELL OFFERS:

Security • Long-Range Programs Excellent Salaries • Opportunity for the engineer who desires professional advancement

AND

Liberal Benefits such as: Tuition Assistance • Retirement Plan • Insurance Benefits • Paid Vacations • Sick Leave

INQUIRE:

Engineering Personnel
Post Office Box One
Buffalo 5, N. Y.

BELL Aircraft CORPORATION

The papers presented at the conference and reproduced here are: Luftfahrt—ein Menschheitsproblem (Aeronautics—a Problem for Mankind), H. Koppe. Die Entwicklung der Windkanäle in den letzten beiden Jahrzehnten (The Development of Wind Tunnels in the Last Two Decades), H. Schlichting. Das Widerstandsproblem; Ein Überblick über den Derzeitigen Stand (The Problem of Drag, A Survey of its Present Status), F. Riegels. Absaugung in der Flugtechnik unter besonderer Berücksichtigung des Forschungsstandes in Deutschland bis zum Jahre 1945 (Aspiration of Flow in Aerodynamic Design, With Special Reference to the Progress of Research in German up to 1945), B. Regenscheit. Schnellflug und Flugzeuggestaltung (High-Speed Flight and Aircraft Design), E. W. Pleines. Leichtbau und Leichtbauforschung im Flugzeubau (Light Structures and Light-Structure Research in Aircraft Design), H. Winter. Developments in the Design of Civil Aircraft, D. J. Lambert. Grundlagen der Flugzeugantriebe (Fundamentals of Aircraft Power Plants), E. Schmidt. Kolbentriebwerke (Piston Power Plants), K. Löhner. Der Entwicklungsstand der Fluggasturbinen, April, 1952 (The Status of Development in Aircraft Gas Turbines in April, 1952), K. von Gersdorff. Strömungsfragen des Stau-Strahltriebwerks (Flow Problems of the Ram-Jet Power Plant), O. Schrenk. Neuzeitliche Ortungsverfahren (Present-Day Methods of Navigation), E. Roessger.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

Notices should be sent directly to:

Institute of the Aeronautical Sciences
2 East 64th Street
New York 21, N.Y.

WITTEK

Aviation

HOSE CLAMPS

Standard of the Industry for Over a Quarter Century

WITTEK Manufacturing Co.
4305-15 West 24th Place
Chicago 23, Illinois

4447

Aetco

EVALUATION TESTS

Save time and headaches when weighing the relative merits of alternative materials, equipment or design.

Rely on AETCO SERVICE for dependable, unbiased evaluation tests . . . fast accurate reports.

General aircraft component testing, including hydraulic, pneumatic, electrical (400 cycle AC-DC) and mechanical.

In-flight testing, too!

Aetco

1806-12 FLEET ST.
BALTIMORE 31, MD.

AIRCRAFT EQUIPMENT TESTING COMPANY

at 30,000 feet over Enemy Territory

-it's got to work!

Pilots of Republic F-84F Thunderstreaks Depend on Soreng Solenoid-Operated Valves to Change Fuel Tanks . . .

Mission accomplished . . . time to head home . . . fuel gauge reads "empty." The pilot flicks a switch . . . and a small valve takes over—cuts a full tank into the fuel line without interruption of flow.

Not just an ordinary valve—but a specially designed Soreng Solenoid-Operated Valve. Engineered to the exacting specifications of the Air Force for the famed F-84F Republic Thunderstreak. It's built to Soreng's own high standards—built to work, *without fail.*

Like all Soreng electrical components, Soreng solenoid-operated valves are custom-designed, custom-engineered and custom-built *at production line prices* in our own extensive plants. Here at Soreng—with more than a quarter century of experience—we have the engineering talent and research facilities to help you develop dependable electrical components for *your* product. Why not get all the facts—*now?*

SORENG

PRODUCTS CORPORATION

9571 Soreng Ave., Schiller Park, Ill. (Chicago Suburb)

Eastern Representative
O. K. Gardner Company
8-219 General Motors Building
Detroit 2, Michigan

Western Representative
Burla Engineering Company
1124 North LaBrea Avenue
Los Angeles 36, California

PLANTS: SCHILLER PARK, ILLINOIS • FREMONT, OHIO • SPRING VALLEY, ILLINOIS

NEW PROTECTIVE COATING CHEMICAL FOR ALUMINUM

ALODIZING

Alodizing with "Alodine,"* a new technique in the protective coating of aluminum, was made available for production-scale use in 1946. Since that time Alodizing has largely supplanted the more elaborate, costly and time-consuming anodic treatments in the aircraft and other industries.

Continuous and successful industrial use has clearly demonstrated the simplicity and economy of the Alodizing process as well as the effectiveness of the "Alodine" amorphous coatings, particularly as a base for paint. In fact, the paint-bond that Alodized aluminum provides has been found to be superior to that possible with chromic acid anodizing.

The corrosion-resistance of unpainted aluminum Alodized with "Alodine" Nos. 100 or 300 is excellent, easily meeting the requirements of Specification MIL-C-5541. However, a need for protection of unpainted aluminum, even better than that obtained with chromic acid anodizing, has long been recognized.

NEW IMPROVED "ALODINE" DEVELOPED By ACP RESEARCH CHEMISTS

Several years of intensive research have now led to a new type of "Alodine," designated as "Alodine" No. 1200. This new protective coating chemical forms an amorphous mixed metallic oxide coating of low dielectric resistance that provides unusually high corrosion-resistance for unpainted aluminum. In addition, it forms an excellent paint bond that approaches closely the high quality obtained with the earlier types of "Alodine."

After having been tested for conformance with Specification MIL-C-5541, "Alodine" No. 1200 is now about to go into production.

PROCESS DETAILS

"Alodine" No. 1200 is the only essential chemical needed to prepare the coating bath and the final rinse bath. One of its unique features is that it can be used in tanks in an immersion process, or, in a multi-stage power washer in a spray process, or, with a slight adjustment of pH, with brush or portable spray equipment in a manual process. This means that even where the simple production equipment is not available, or where touching up of damaged coatings previously Alodized or anodized is required, excellent protection and paint bonding can still be obtained with practically no equipment.

All three methods of application easily meet the requirements of Specification MIL-C-5541.

Process sequence for all three methods of application is the same as for other standard grades of "Alodine" such as Nos. 100, 300, and 600, viz.: 1. Pre-cleaning. 2. Rinsing. 3. Alodizing. 4. Rinsing. 5. Acidulated rinsing. 6. Drying.

Coating time in an immersion process ranges from 2 to 8 minutes and in a mechanized spray process is about 30 seconds. "Alodine" No. 1200 baths are operated at room temperatures (70° to 100°F.) and heating is required only if the bath has gotten cold after a "down" period.

RECOMMENDED USES FOR "ALODINE" No. 1200

"Alodine" No. 1200 is specifically recommended for coating wrought products that are not to be painted or are to be only partially painted; and for coating casting and forging alloys whether or not these are to be painted. "Alodine" Nos. 100 and 300 are still recommended for coating wrought products such as venetian blind slats, awnings, etc., that are invariably painted.

RESULTS OF TENSILE TESTS

This new "Alodine" not only retards visible corrosion and pitting, but as shown in the table below, the loss of ductility with "Alodine" No. 1200, both brush and dip, after 1000 hours salt spray was less than for chromic acid anodizing after 250 hours, and for "Alodine" No. 100 and a conventional chromate treatment after 168 hours exposure.

PROCESS	SALT SPRAY EXPOSURE	COMPLIANCE WITH TENSILE REQUIREMENTS OF MIL-C-5541
CHROMIC ACID ANODIZING	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	fails
	1000 hrs.	fails
BRUSH "ALODINE" No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 100	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails
CONVENTIONAL CHROMATE TREATMENT	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails

*"Alodine" Trade Mark Reg. U. S. Pat. Off.

CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY

General Offices: Ambler, Penna.

Detroit, Michigan **Niles, California** **Windsor, Ontario**

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Aeronautical Design Engineer—GS-11, $5,940 per annum. Post of duty, Washington, D.C., with occasional travel. Duties: Technical supervision and coordination of Coast Guard aircraft acquisition, construction, and improvement program; preparation, study, and evaluation of specifications; initiating changes in design to conform to needs of Coast Guard; resolution of engineering and production conflicts; correspondence and reports. Requirements: A full 4-year professional engineering curriculum leading to a Bachelor's Degree in an accredited college or university plus 2½ years of aeronautical engineering experience, which must have demonstrated a good knowledge of engineering principles and the ability to perform engineering work under only general supervision. Address replies to: Chief, Civilian Personnel Division, U.S. Coast Guard, Room 3006, 1300 E Street, N.W., Washington 25, D.C.

Professor or Associate—The Brazilian Aeronautical Technical Institute needs high-grade professors specialized in aerodynamics, structures, and airplane design for further development of undergraduate and graduate courses and of laboratories. Prefer men with Ph.D. and teaching experience, but will consider applications from men with sound theoretical training plus practical experience. Salary and rank dependent on qualifications. Unusual opportunity for the right persons. Inquiries should be sent to Professor A. J. Meyer, ITA, COCTA, São José dos Campos, São Paulo, Brazil. Please include detailed information about education, experience, contributions, etc.

Engineers, Technologists, Physicists, Physiologists, Metallurgists—The Navy Air Material Center located in the U.S. Naval Base at the extreme south end of Broad Street in Philadelphia, Pa., has vacancies in the above positions for qualified eligibles. These vacancies are at grade GS-5 to GS-12 level with salary ranging from $3,410 to $7,040 per annum. The Naval Air Material Center (the Air Center is divided into three major branches: the Naval Aircraft Factory, the Naval Air Experimental Station, and the Naval Auxiliary Air Station) is engaged in research (applied), development, manufacture, modification, test evaluation, and overhaul of aircraft, aircraft components, and aeronautical materials, including launching and arresting devices. This activity has the job of finding the answers to a never-ending series of problems involving the whole field of aeronautical sciences. Interested persons should file an Application for Federal Employment, Standard Form 57, with the Industrial Relations Department, Naval Air Material Center, Naval Base, Philadelphia 12, Pa. Applications may be obtained from the Industrial Relations Department, Naval Air Material Center, or at any first- or second-class Post Office or from any Civil Service Regional Office.

The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

532. Research Engineer—Recently organized Research and Development Division of medium-size aircraft components corporation in Ohio requires the services of senior graduate research engineer for new product analysis. Applicant should be intimately acquainted with heavier type of production machine tool equipment and have extensive experience in the aircraft or auto-

Roy W. Lessard, Assistant Chief of Design. Has had extensive aeronautical design and structures experience with many leading aircraft manufacturers and is part of the Fairchild engineering team.

Engineers

AN INVITATION TO YOU TO GO PLACES WITH FAIRCHILD

A secure future, exceptional opportunities for advancement, and a high starting salary await you at FAIRCHILD. We have openings right now for qualified engineers and designers in all phases of aircraft manufacturing.

Paid vacations, liberal health and life insurance coverage. Premium is paid when longer work week is scheduled.

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD *Aircraft Division*
HAGERSTOWN, MARYLAND

CONVAIR
IN FRIENDLY FORT WORTH, TEXAS

Offers Opportunity For
SENIOR AERONAUTICAL ENGINEER
THEORETICAL AERODYNAMICS

Send resumé of training and experience to M. L. TAYLOR,
ENGINEERING PERSONNEL DEPT. 6-U

CONSOLIDATED VULTEE AIRCRAFT CORP.
FORT WORTH, TEXAS

When you write to manufacturers whose advertising appears in the **Aeronautical Engineering Review,** it will be of interest to the companies and of benefit to the Institute if you mention that you saw it in the **Aeronautical Engineering Review**

Engineers

Join the Sabre Builders

Insure your future with North American Aviation. The Engineering Department has challenging openings for engineers with aircraft experience, for recent grads... for men from other fields with adaptable experience. Twenty-five years of engineering vision and expansion and long term military projects secure your future. Openings now in:

THERMODYNAMICS • AERODYNAMICS
SYSTEM ANALYSIS • STRUCTURES
SERVO-MECHANISMS • ELECTRONICS
SPECIALISTS IN ALL MAJOR AIRCRAFT FIELDS

Liberal travel and moving allowances

Write to

North American Aviation, Inc.

Section 1
Engineering Personnel Office
Los Angeles International Airport
Los Angeles 45, California
or
Columbus 16, Ohio

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD

ENGINEERS—

Experienced in Catapult or Similar Equipment...
ALSO ENGINEERING TRAINEES

Aircraft Catapult and arresting gear dept. in AAAA midwest firm has permanent positions in design section. Hydraulic and mechanical machinery experience considered. Equipment now being manufactured by this newly-organized dept. may become basic ground gear for modern high-speed planes, both military and civilian.

This 100-year-old firm pays top wages and provides many other benefits. Imaginative engineers, aged 25 to 40, interested in this expanding field should send resume to:

Aeronautical Engineering Review
Box 538

motive fields. Salary commensurate with experience.

530. Design Engineers, Aerodynamicists—Minneapolis firm has openings for experienced aircraft structural and instrument designers. Degree not required if strong experience record is demonstrated. Minimum 5 years' experience required in responsible work. Aerodynamicists needed for subsonic and supersonic theory and applied design. Degree and minimum 2 years' experience required in this field. Opportunity for graduate work at nearby university for qualified applicants.

Available

529. Staff Engineer—12 years' aircraft experience, including stress, liaison, design, production design, Air Force procurement and maintenance engineering, and project engineering. Currently on project staff assignment with aircraft manufacturer. Desires responsible staff engineering position with smaller manufacturer on West Coast. Please state your requirements in first letter.

527. Aeronautical Engineer—Age 30. Bachelor of Aeronautical Engineering, 1948. Five years' experience in jet-engine combustion component research, design and development involving thermodynamics, internal aerodynamics, test facility design and evaluation, and heat transfer. Commercial pilot with instrument rating. Desires more responsible technical and administrative position. Will consider non-aviation or foreign association. Résumé furnished upon request.

526. Administrative—Aeronautical Engineer, B. of A.E. Desires administrative or technical position with United States firm either at home or abroad. Extensive aeronautical experience (design, structures, and production), as well as administrative experience (systems and new

Staff Engineer
ARMAMENT

We have an attractive opening for a staff specialist in the design of aircraft armament systems, armor, and their installations. Duties include responsibility for evaluating various aircraft armament systems, the preparation of basic armament design specifications and the technical direction and administration of armament testing.

Applicants should have experience as an engineering specialist in a large design organization. Job requirements include engineering degree plus eight to ten years' experience in various aircraft armament fields, such as aircraft guns, ammunition chutes, ammunition feeders (including related pneumatics) and rockets (including pack design).

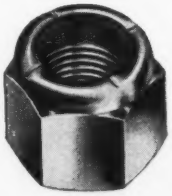
All inquiries will be held confidential. For further consideration submit letter of application to:

ENGINEERING PERSONNEL SECTION
CHANCE VOUGHT AIRCRAFT
P. O. Box 5907 Dallas, Texas

DIVISION OF UNITED AIRCRAFT CORPORATION

self-locking fasteners

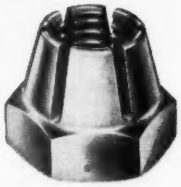
Elastic Stop nuts


HEX NUT

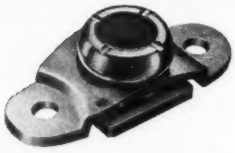
SPLINE NUT

HIGH TENSILE NUT

CLINCH NUT


1200° F. HIGH-TEMP. NUT

GANG CHANNEL NUTS


FLOATING ANCHOR NUT

Every major aircraft now being assembled relies on the vibration-proof holding power of ELASTIC STOP nuts. Only ESNA manufactures a complete line of all types and sizes of self-locking nuts.

Rollpins

dia. from 1/16" to 1/2"

Rollpins are slotted, tubular steel, pressed-fit pins with chamfered ends. They drive easily into holes drilled to normal tolerances, compressing as driven. Extra assembly steps like hole reaming or peening are eliminated. Rollpins *lock* in place, yet are readily removed with a punch and may be reused.

Cut assembly costs by using Rollpins as set screws, positioning dowels, clevis or hinge pins. Specify them in place of straight, serrated, tapered or cotter type pins.

ESNA® TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

ROLLPIN TRADEMARK

Mail Coupon for Design information

Elastic Stop Nut Corporation of America
Dept. N34-1158 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

- ☐ Elastic Stop Nut Bulletin
- ☐ Rollpin Bulletin
- ☐ AN-ESNA Conversion Chart
- ☐ Here is a drawing of our product. What fastener would you suggest?

Name_____ Title_____

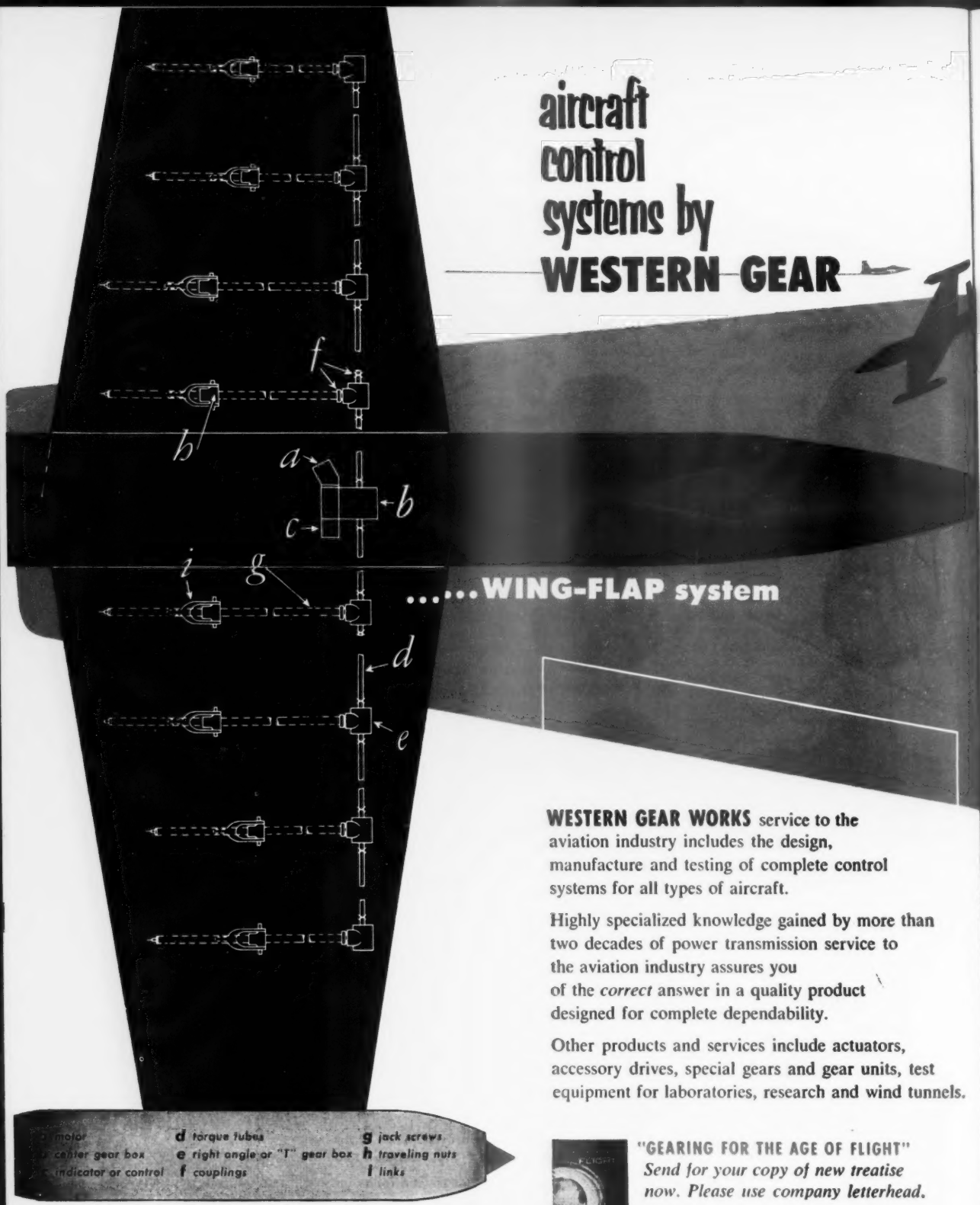
Firm_____

Street_____

City_____ Zone____ State_____

DEPARTMENT OF TECHNOLOGY BUFFALO PUBLIC LIBRARY

aircraft control systems by WESTERN GEAR



.....WING-FLAP system

motor
b center gear box
c indicator or control
d torque tubes
e right angle or "T" gear box
f couplings
g jack screws
h traveling nuts
i links

WESTERN GEAR WORKS service to the aviation industry includes the design, manufacture and testing of complete control systems for all types of aircraft.

Highly specialized knowledge gained by more than two decades of power transmission service to the aviation industry assures you of the *correct* answer in a quality product designed for complete dependability.

Other products and services include actuators, accessory drives, special gears and gear units, test equipment for laboratories, research and wind tunnels.

"GEARING FOR THE AGE OF FLIGHT"
Send for your copy of new treatise now. Please use company letterhead.

5314

WESTERN GEAR WORKS
Manufacturers of **PACIFIC-WESTERN** Gear Products
Pacific Gear & Tool Works

Plants: Seattle
San Francisco
Belmont (S. F. Peninsula)
Lynwood (Los Angeles County)
Houston

Plants—417 Ninth Ave. S., Seattle 4, Washington
2600 E. Imperial Highway, Lynwood (Los Angeles County), California
1035 Folsom St., San Francisco 3, California
Belmont (San Francisco Peninsula), California
117 N. Palmer St., Houston 3, Texas

Representatives—N. 2605 Division St., Spokane, Washington
930 S. E. Oak St., Portland 14, Oregon
Room 212, Ross Bldg., Denver 2, Colorado
500 South Ervay Street, Dallas, Texas
Engineering & Machinery Ltd., 1366 W. Broadway, Vancouver, B.C.

products). Excellent personal and professional references. Salary of secondary importance to opportunity. Present position as an Administrative Engineer for an air line.

525. Aviation Executive—Captain, Naval Air Reserve. Twenty-five years' Naval aviation flight and executive experience; 6,500 hours all types, including jet. Current commercial license instrument rated. Desires connection with aviation accessories, manufacturers, oil companies, or airport management. Utilization of flight ability with position if necessary. Salary commensurate with position and advancement opportunities.

523. Engineer—Executive; B.S. in Aeronautical Engineering. Ten years' diversified experience, including engineering, tooling, service engineering, and manufacturing. Recent administrative and supervisory experience. Desires responsible position utilizing diversified background. Résumé upon request.

522. Sales Engineer—B.S. in C.E. Fifteen years' diversified aircraft experience, including design, estimating, and planning. Presently employed. Current salary $8,000. Well acquainted with all phases of aircraft industry. Recent aptitude tests indicate outstanding sales ability. Would like to represent equipment manufacturer contacting aircraft and metal-working industry. Prefers Midwest or Dallas-Fort Worth area.

521. Aeronautical Engineer—Age 35. Thirteen years' experience covering structural and mechanical design, flight-test engineering, liaison, field service, and project work. Well acquainted with all phases of airplane and missile operation and design. Desires position of responsibility in administrative engineering or sales of aircraft, petroleum, or air-line company. Prefers West Coast. Top professional and personal references.

520. Aeronautical Engineer—B.S.E., University of Michigan, specializing in propulsion. Commercial pilot. Presently employed with a West Coast aircraft company in the test department; 18 months' experience in test including jet-engine testing. Desires to relocate in the East or Midwest. Air Force veteran, married, age 29.

519. Field Engineer, Sales and Service—B.S.Ae.E. Age 31. Varied experience in aeronautical, mechanical, and electronic fields. Extensive travel through Europe as senior field engineer on radar and gun-fire control equipment, both air-borne and antiaircraft. Extensive experience as instructor on air-borne gun-fire control equipment, in various languages. Speaks, reads, and writes Spanish, French, Italian, Portuguese, and English. Desires responsible position as Foreign Field Engineering Representative in Europe or South America. Please indicate the nature and salary range of available positions.

518. Engineer, Research Administrator—B.S.A.E., B.S. in Business and Engineering Administration, M.I.T. Eleven years' broad experience as engineer, test pilot, consultant, educator, and, most recently, administrator of government research and development activities, United States and abroad. Desires connection in the organization and management of technical and scientific activities. Preferred location northeastern United States.

517. Aeronautical Engineer—B.Aero.E. Engaged 10 years in wind-tunnel research at high subsonic and transonic speeds. Active in problems of stability and control, wing-performance, wing-fuselage interference, propeller aerodynamics, and propeller vibrations. Experience also in the design and testing of wind-tunnel fans. Has completed course work in graduate training program leading to Master's Degree. Desires position in research and development or supervisory position connected with research and development. Preferable location east of Illinois and north of Virginia.

516. Engineering Pilot—B.S.Ae.E., 1942. Age 35. Eighteen years' flying experience. Air-line transport pilot rating, single- and multi-engine land CAA instrument and flight instructor ratings: 3,800 hours flying time; 3,000 hours multiengine. One year part-time C.P.T. primary and secondary flight instructor. Three and one-half years' flight-test experience with manufacturer as experimental test pilot. Thorough engineering and flight background in aircraft performance, stability, controlability, and power-plant performance testing. Five years with air lines as air-line pilot, instrument and aircraft flight instructor, engineering and maintenance test pilot, and consulting engineer. Experience in both domestic and overseas air-line piloting on DC-3, DC-4, DC-6, and Constellation aircraft. Thorough working background in flight analysis with emphasis on aircraft performance as applied to CAA Transport Category. Has engaged in development of pilots' aircraft operating manuals and flight training manuals for aircraft manufacturer and air lines. Two years' experience in electronic and supersonic aircraft development work. Desires engineering pilot position with air line or manufacturer.

515. Structural Engineer—Bachelor of Aeronautical Engineering, 1946. Seven years' experience in aircraft stress analysis, including 1 year of static test at Wright Field as company representative. Desires stress analyst position. Résumé furnished upon request.

514. Aeronautical Engineer—Age 41. Degree of Aeronautical Engineer. Twenty years' experience in various phases of engineering. Thirteen years of aircraft design, preliminary design, and USAF. Seven years guided missiles, electromechanical design, and research in electronic air-borne equipment. Of experience noted, 12 years has been at the design supervision level. Desires position as staff engineer, consultant, or group leader in preliminary design in aircraft field. Detailed professional history furnished on receipt of letter describing position.

513. Mechanical Engineer—Age 25. Broad experience in aviation, including military and civilian pilot; 2,000 hours, single- and multi-engine, instrument, and instructing experience. Heavy experience in 4-engined DC-4 transport aircraft. Qualified all phases of flight operations and control. Engineering experience in research and writing on propellers and propeller controls. Recent field service engineering experience in capacitance-type fuel gages in combination with corporation pilot. Desires position with airframe, engine, instrument, or component manufacturer in flight test, operations or field engineering, or sales engineering.

512. Aeronautical Engineer—M.S. degree. Age 37. Fourteen years' experience in preliminary design, design aerodynamics, and structures of aircraft and guided missiles. Presently engaged as a supervisory design engineer in preliminary design analyses of guided missiles. Present salary in excess of $8,000. Desires responsible position in or related to aircraft or missile preliminary design or weapon-systems analysis.

511. Structural Engineer—Bachelor of Civil Engineering (magna cum laude) and Master of Applied Mechanics. Nine years' original research in elastic stability, plates and shells, aircraft stress analysis, sandwich theory, creep, and high-temperature problems. Supervisory and high-speed digital computing experience. Can be valuable as research engineer, stress analyst, structural consultant, applied mathematician, or teacher. Age 29.

510. Engineering Instructor—Ph.D. in applied mechanics (with background in A.E. & M.E.). Ten years' teaching and research experience in colleges. Currently engaged in structural research in aircraft industry. Desires a teaching and/or research position in college. Résumé furnished on request.

509. Aeronautical Engineer—B.A. and M.E. Age 48. Broad professional experience in aerodynamic research and development. Six years' teaching thermodynamics, aerodynamics, and structures. Would like position in school with E.C.P.D. accreditation or equivalent aim.

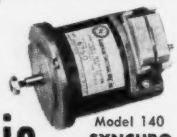
Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other IAS members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

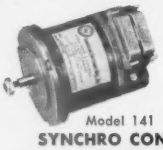
Items will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th Street, New York 21, N.Y.

In large scale production NOW!

American Electronic



Model 140
SYNCHRO GENERATORS



Model 141
SYNCHRO CONTROL TRANSFORMERS

A pair with an established reputation.
The heart of modern two-speed systems.

AVAILABLE FOR IMMEDIATE DELIVERY:

Size 15
UNIVERSAL-FREQUENCY PRECISION RESOLVER
Minimum noise, highest accuracy. Basic to all trigonometric operations.

Size 15
UNIVERSAL-FREQUENCY PRECISION POTENTIOMETER
Continuous rotation, induction type. Accuracy comparable to resolver.

Model 171
SERVO COMPUTING TACHOMETER
Companion to Model 172 Servomotor. Superior linearity and signal-to-noise ratio

Model 172
SERVO CONTROL MOTORS
"Standard" in many modern computers and controls. Thousands in use

FEATURES

- Maximum accuracy, signal-to-noise ratio, range of linear operation.
- Minimum noise, size and friction.
- Total magnetic shielding.
- Internal winding or external network compensation.
- High temperature resistant models.
- Corrosion and fungus resistant.
- Complete line of "packaged" compensating isolation driver-amplifiers.
- Reliable delivery commitments.

READY FOR FALL DELIVERY:
Sizes 11 and 23 Induction Resolvers and Potentiometers · Sizes 11 and 15 Servo Control Motors and Computing Tachometers · Model 293 Brushless Potentiometers.

American Electronic Mfg., Inc.
9503 W. Jefferson Blvd., Culver City, Calif.

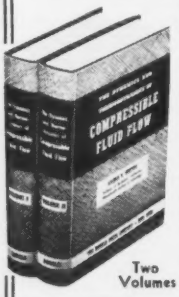
Just Published

The Dynamics and Thermodynamics of Compressible Fluid Flow

ASCHER H. SHAPIRO
Massachusetts Institute of Technology

NEW—the only complete, single-source reference work covering virtually all aspects of compressible fluid mechanics. Ranging in scope from fundamentals to analytical development of design methods and advanced exemplary methods, the book organizes a fund of up-to-date material directly applicable to the engineering problems that arise in high speed aircraft and rocket design.

Discussions are based on a combination of clear physical reasoning, theoretical treatment, and experimental results, designed to create a book of high practical value for engineering purposes. All important results are reduced to chart form, while an appendix provides numerical tables to facilitate computation of compressible-flow functions. *Vol. I, 660 pp. 603 ills., ready now. Vol. II, 600 pp., 580 ills., ready Spring 1954.*



Two Volumes *Set, $30. Single Vol., $16.*

AIRSURANCE
Airline Passenger Insurance

Annual Policies from $5,000 to $100,000 at new low rates

No Physical Examination • No Age Limit

EXAMPLE
$25,000.00 for death or dismemberment
$1,000.00 for Hospital and Doctor's bills
$50.00 per week when disabled
PREMIUM $38.00 per year

Policies cover passengers on scheduled airlines WORLD-WIDE

Write or phone your Insurance Agent

U.S. GROUP

Backed by the Combined Assets of
Aetna Casualty & Surety Co.
American Employers' Insurance Co.
American Surety Co. of N. Y.
Century Indemnity Company
The Employers' Liability Assurance Corp., Ltd.
Hartford Accident & Indemnity Co.
Maryland Casualty Co.
Massachusetts Bonding & Insurance Co.
New Amsterdam Casualty Co.
Standard Accident Insurance Co.
Travelers Insurance Co.
United States Casualty Co.
United States Fidelity & Guaranty Co.

UNITED STATES AVIATION UNDERWRITERS
INCORPORATED
80 JOHN ST. • NEW YORK 38, N. Y.
ATLANTA · CHICAGO · DALLAS · KANSAS CITY
LOS ANGELES · SAN FRANCISCO

* * *

COMING IN DECEMBER ISSUE

AERONAUTICAL ENGINEERING REVIEW

"ENGINEERING TRENDS FOR 50 YEARS"

A Special Issue Commemorating the 50th Anniversary of Powered Flight

* * *

Gas Turbines

HARRY A. SORENSEN
State College of Washington

PROVIDES a valuable working knowledge of the gas turbine as a power plant which can—through modifications in design and construction—be applied to many classes of service. Covers thermodynamic principles, elements of design, and general construction features of the gas turbine power plant. Includes recent advances made in aircraft gas-turbine engines and jet propulsion; stresses axial-flow compressors and turbines. Duplication is avoided throughout by organization by topic and function rather than by type of power plant. Operating data included. *432 ills., 469 pages.* **$6.50**

Similitude in Engineering

GLENN MURPHY
Iowa State College

ORGANIZES and thoroughly analyzes the problems of model design and the interpretation of model tests. First book to show how scale models may be used to work out problems not easily solved by analytical means. Complete coverage of dimensional analysis used in the development of scale models; design of distorted models and their application to the problems of engineering; and the analogous relationship of the scale model to the actual structure. *56 ills., 302 pages.* **$7**

At your bookstore or direct from . . . .

THE RONALD PRESS COMPANY
15 East 26th Street, New York 10